Exploring the Prevalence of Developmental Reading Difficulties in Children with Fetal Alcohol Spectrum Disorders

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COMPULSORY DECLARATION

This work has not been previously submitted in whole, or in part, for the award of any degree. It is my own work. Each significant contribution to, and quotation in, this dissertation from the work, or works, of other people has been attributed, and has been cited and referenced.

Signature:_____ Date:_____

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ABSTRACT

Background. As part of a large ongoing research programme concerned with the teratogenic effects prenatal alcohol exposure has on the developing brain, this study investigated whether developmental reading difficulties are present in school-going children with fetal alcohol spectrum disorders (FASD). Whereas the diagnostic facial anomalies associated with FASD are well documented, cognitive deficits remain largely unexplored. Some neuropsychological reviews include deficits in reading as part of the FASD cognitive profile; however, the extant empirical research investigating reading abilities in children with FASD is limited. Therefore, the specific objectives of the current study were to explore the prevalence and characteristics of developmental reading skill deficits in a sample of children with FASD.

Methods. Participants were 46 children (9-13 years) who had previously been diagnosed as either prenatally exposed or non-exposed. Of the 32 exposed children, 7 met the criteria for fetal alcohol syndrome (FAS), 3 met the criteria for partial FAS (pFAS) and 22 did not meet the criteria for diagnosis of FAS/pFAS but were still heavily exposed (and were thus characterized as "other heavily exposed", or OHE). All participants were administered the Neale Analysis of Reading Ability (NARA; a measure of reading speed, accuracy, and comprehension) and the Phonological Assessment Battery (PhAB; a measure of phonological awareness, processing speed and fluency). Independent samples *t*-tests and one-way analyses of covariance (ANCOVAs) were performed to determine if there were statistically significant between-group differences in a two-group (exposed versus non-exposed) or three-group (FAS/pFAS versus OHE versus control) comparison. Multiple regression-based analyses were performed to determine if a relationship existed between a continuous measure of prenatal alcohol exposure and the outcome measures. Within each of these analyses an estimate of IQ was used to determine if the effects seen were present even with that covariate taken into account.

Results. None of the two- or three-group analyses showed any statistical significance on the PhAB or NARA outcome variables. Participants in the FAS/pFAS and OHE groups performed significantly differently on the PhAB non-phonological fluency performance measure; this between-group difference was not in the predicted direction, however, and probably resulted from artifactual factors. Results from the multiple regression-based analyses showed that associations between the predictor variable (level of prenatal alcohol exposure) and two outcome variables (phonological production speed and reading rate abilities) approached, but did not reach, statistical significance.

Conclusion. Overall, the data suggest that impairments in phonological awareness, phonological processing speed, verbal fluency, and developmental reading difficulties are not characteristic of the cognitive profile of children with FASD. These findings are not conclusive, however, due to several limitations in the current study. These limitations are discussed and provide interesting insight into the process of assessing phonological abilities and reading skills in this population. Further research, using a broader range of assessment tools and a larger sample size, is necessary in order to provide a more detailed and definitive analysis of these abilities. Nonetheless, the current study shows that the evaluation of reading and phonological disorders in FASD is an important and worthwhile endeavour.

INTRODUCTION

Whereas the diagnostic facial anomalies associated with fetal alcohol spectrum disorder (FASD) have been well documented, cognitive deficits have remained largely unexplored. To better understand the pathophysiology of the disorder, there is a need to explore the cognitive deficits characteristic of FASD. The specific objectives of the current study are to explore the phonological abilities and the prevalence of developmental reading skill deficits in school-aged children who were exposed to alcohol prenatally. This knowledge may help inform researchers and clinicians of some possible cognitive characteristics within FASD as well as direct possible intervention programmes.

Diagnostic Criteria: Fetal Alcohol Spectrum Disorder

Fetal alcohol spectrum disorder (FASD) is a non-diagnostic umbrella term referring to the continuum of physical malformations, cognitive deficits and behavioural problems associated with prenatal alcohol exposure. This continuum extends from, at the severe end, *fetal alcohol syndrome* (FAS) to a group of less severe disorders categorised by *fetal alcohol effects* (FAE; Jacobson & Jacobson, 2002; Lewis & Woods, 1994; O'Leary, 2004).

In order for a diagnosis of FAS to be made, a history of heavy prenatal drinking must be recorded. Heavy prenatal alcohol exposure ranges from binge drinking (dangerously large quantities of alcohol in one drinking session) to continual alcohol consumption throughout the prenatal period. The precise quantities of alcohol that place the fetus at risk are unknown. Pietrantoni and Knuppel (1997) estimate that 28-140g ethanol (1.5-8 drinks) per week increases the chance of the fetus developing FAS by 10%. This percentage increases dramatically (to up to 40%) when more than 140g of ethanol (more than 8 drinks) is consumed in 1 week. If the criterion of heavy prenatal drinking cannot be met it is essential that all other diagnoses have been eliminated before a diagnosis of FAS is made (Bolton, 1983).

In conjunction with prenatal alcohol exposure, a triad of characteristics need to be present for a diagnosis of FAS to be made: characteristic facial phenotype, pre- and post-natal growth retardation, and central nervous system (CNS) anomalies. *Facial phenotype characteristics* include shortened palpebral fissure, flattened midface, flat and thin upper lip, and little or no philtrum and epicanthal folds. *Growth retardation* is identified by low birth weight to height

ratio, low birth weight for the gestational period, and deficient catch-up development not attributable to poor nutrition. *CNS anomalies* typically include small head size at birth, neonatal irritability and feeding problems, hyperactivity in childhood, developmental delay, intellectual disability, hypotonic muscle tone, poor eye-hand co-ordination, poor fine motor skills, hearing loss not related to injury or illness and feeble gait when walking (Jacobson & Jacobson, 2002; O'Leary, 2004; Whitty & Sokol, 1996).

Partial fetal alcohol syndrome (partial FAS), alcohol-related birth defects (ARBD), and alcohol-related neurodevelopmental disorder (ARND) all fall under the categorical umbrella term FAE. Those children who are known to have been exposed heavily to alcohol in utero and who show some, but not all, of the characteristics of FAS are diagnosed as showing FAE. These children tend to have IQ scores within the borderline-to-average range and milder behavioural problems than those typically associated with FAS (Batshaw & Conlon, 1997). If the history of maternal drinking during pregnancy is unknown the physician may make the FAE diagnosis if he is certain the characteristics seen cannot be attributed to any other disorder (Jacobson & Jacobson, 2002; Sokol & Clarren, 1989).

Children diagnosed with partial FAS must display some of the characteristic facial dysmorphic features of FAS and exhibit abnormalities in at least one, but not all, of the following domains: growth retardation, CNS anomalies, and non-age appropriate cognitive and/or behavioural difficulties that cannot be explained solely by genetic or social factors. The ARBD diagnosis is applied to children in the FAE category who have normal facial phenotypes, growth and development but who have congenital abnormalities related to the heart, skeleton, eyes, ears and/or kidneys. A diagnosis of ARND can be made when a child presents with one or both of the following: CNS problems and cognitive and/or behavioural abnormalities typical of FAS and partial FAS. These neurobehavioural deficits are, however, generally more subtle than those seen in children with FAS or partial FAS, and lowered IQ scores are not found in children with ARND. Furthermore, the neurobehavioural abnormalities characteristic of ARND are generally atypical of what is seen in other family members who were exposed to alcohol prenatally, and cannot be explained by social-environmental influences alone (Jacobson & Jacobson, 2002).

FASD Cognitive and Behavioural Profile

Unlike the well-defined facial phenotype associated with prenatal alcohol exposure, the broad range of cognitive and behavioural profiles associated with FASD are somewhat amorphous. Intelligence quotients for children diagnosed with FAS range from 20 to 100, with the average nearing 70 (Mattson & Riley, 1998). This variance is most likely due to differing *in utero* exposure levels as well as differing socioeconomic environments in tested samples (Kodituwakku, 2007). Evidence from repeated IQ testing suggests that general intellectual functioning is largely stable across time, with verbal and nonverbal IQ skills being similarly affected (Mattson & Riley, 1998; Streissguth, Herman & Smith, 1978). Children who do not meet the criteria for a diagnosis of FAS but who do meet the criteria for partial FAS or ARND may still experience mental retardation or the effects of lowered IQs (Mattson & Riley, 1998).

Many review articles outline the behavioural and cognitive deficits observed in children with FASD (see, e.g., Church & Kaltenbach, 1997; Conry, 1990; Kodituwakku, 2007; Mattson & Riley, 1998; O'Leary, 2004). Deficits in executive functioning (Connor, Sampson, Bookstein, Barr & Streissguth, 2001; Mattson, Goodman, Caine, Delis, & Riley, 1999),working memory (Burden, Jacobson, Sokol, & Jacobson, 2005; Kodituwakku, Handmaker, Cutler, Weathersby & Handmaker, 1995), cognitive processing speed (Streissguth, Barr & Sampson, 1990; Jacobson, Jacobson, Sokol, Martier, & Ager, 1993, Burden, Jacobson & Jacobson, 2005), and arithmetic, over and above the influence of IQ (Carmichael Olsen, Feldman, Streissguth, Sampson, & Bookstein, 1998; Goldschmidt, Richardson, Stoffer, Geva, & Day, 1996), are consistently reported within the literature. Deficits in attention (Nanson & Hiscock, 1990), visual-spatial skills (Carmichael Olsen, et al., 1998), learning and memory (see, Mattson & Riley, 1998), and language and speech (Shaywitz, Caparulo, & Hodgson, 1981) are also reported, but the findings associated with these deficits are not altogether consistent (Goldschmidt et al., 1996).

Although the prevalence of reading deficits in FASD is briefly mentioned within the literature (Batshaw & Conlon, 1997; Streissguth, et al., 1990), there are few studies reporting significant evidence to support the inclusion of a reading skill deficit within the typical FASD behavioural and cognitive phenotype. The proceeding literature review of articles exploring reading abilities in children with FASD demonstrates the scarcity of findings within this area of research.

Streissguth et al. (1991) found the average academic functioning for reading skills in adolescents and adults with FAS-FAE (between the ages of 12 and 40) to be equivalent to a fourth grade level. Substantial reading skill variability within the sample ranged from illiteracy to high school-level reading skills. Unfortunately, the authors included no information regarding the measures they used, and did not provide an in-depth discussion of these reading deficits.

Goldschmidt et al. (1996) assessed the reading abilities of 552 6-year-old children exposed to alcohol prenatally. They found that, even after controlling for IQ, alcohol exposure was significantly associated with reduced scores on measures of reading abilities. The timing of this relationship is specific to the second trimester of the pregnancy and represents a threshold relationship (1 drink/day). Their assessment of reading abilities included the reading subtests of the *Wide Range Achievement Test – Revised* (WRAT-R; Jastak, Wilkinson, & Jastak, 1975) which assesses letter and word naming abilities. Letter naming abilities are more representative of processing speed abilities than a specific reading ability therefore suggesting that, in addition to reading difficulties as assessed by word naming, a phonological processing speed deficit may be characteristic of the cognitive phenotype of FASD. The phonological assessment battery used in the current research measures phonological processing speed performances on picture and digit naming subtests.

Sampson et al. (1997) examined the relationship between prenatal alcohol exposure and reading rate, comprehension, and memory skills using the computer-based, the *Rapid Single Visual Representation* task (RSVP; Kintsch & VanDijk, 1978) task. The results from this study are of particular importance to the current research in that reading rate and comprehension comprise two of the three measures being tested. The task used in the current research measures reading rate, comprehension and accuracy. In the RSVP task, the participant reads a story about four friends going on a hike. Each word in the story is presented separately in the middle of the screen; the rate at which the words are presented is controlled by the reader (he/she presses the space bar to remove the current word and replace it with the next one). Reading speed is therefore measured at three points: the time taken to read the first, interior and last words of the sentences.

At intermittent stages within the story the reader is stopped and three multiple-choice questions (memory, anaphoric and inference) are presented on the screen. Each of the

questions is related to the passage that has been read. One question asked about the facts presented in the story (memory question). The second question tested one's ability to process information when pronouns were used for reference (anaphoric reference question). The third question tested one's ability to make conclusions from information given implicitly in the story rather than explicitly (inference question). The memory questions test the reader's memory abilities and the anaphoric reference and inference questions test the reader's comprehension abilities.

The authors found that reading speed was faster for the beginning word of the sentence and the interior of the sentence and slower for the last word of each sentence. They reasoned that readers slowed down toward the end of sentences in order to incorporate the meaning of all the words within those sentences. Furthermore, participants performed more poorly on the (relatively more difficult) anaphoric and inference questions than they did on the (relatively easier) memory questions. The relationship between comprehension and memory performance was positively correlated with reading speed (more specifically the speed of final word reading): The more time spent reading each word the more accurate the reader's performance was on multiple-choice questions.

Finally, the authors reported that amount of prenatal alcohol exposure was highly significantly associated with performance on the anaphoric questions: Adolescents exposed to higher alcohol levels prenatally performed less accurately on the anaphoric reference questions. Similarly, a moderate relationship existed between alcohol exposure and reading time for the last word of sentences: Adolescents exposed to higher alcohol levels prenatally read the last words of the sentences slightly more quickly than did adolescents exposed to lower levels of alcohol prenatally (Sampson et al., 1997).

Olsen, Feldman, Streissguth, Sampson, and Bookstein (1998) compared the performances of nine adolescent with FAS to a cohort group (adolescents either minimally exposed or non-exposed to alcohol prenatally) as well as to a comparison IQ group (IQ scores within 10 points of the mean IQ of the FAS group) on the RSVP subtests and the *Word Attack* (WA) subtest of the *Woodcock Reading Mastery Tests* (Woodcock, 1987). WA is a phonological processing and reading decoding task. Test-takers are assessed on how well their pronunciation of 45 non-words (random strings of consonants and vowels) adheres to the

grammatical rules in English. Performance on the WA subtest is independent of IQ and is not confounded by other reading dimensions (such as guessing from context).

The performance of the FAS group on the RSVP comprehension subtest was less accurate than the performance of the larger cohort group. Performance similarities of the FAS group and the IQ group suggest an IQ effect on reading comprehension abilities. No between-groups differences were present with regard to RSVP reading speed and the WA performances.

The following study by Adnams et al. (2007) is of particular importance to the current study as it is the only known study which reports on the literacy and phonological skills within a South African sample (65 9-year-old children). Phonology is the study of the distribution and patterning of speech in language, rather than their meaning or grammatical structures. There is a well-established link between phonological awareness abilities and reading skill performances (Stahl & Murray, 1994). Reading ability was assessed using *The University of Cape Town Reading Test*. Significant differences were found between the performances of the children with FASD and the non-exposed children thereby proving the presence of an alcohol effect on reading ability. Interestingly the results from this test show that these non-exposed children from a disadvantaged community in the Western Cape are performing below average for South African normed reading abilities. Phonological awareness skills were assessed using an adapted and translated Afrikaans version of the *Phonological Awareness and Early Literacy Test* (PAELT; Byrne & Fielding-Barnsley, 1993). Exposure to alcohol prenatally resulted in a phonological representation deficit (as the two exposed groups performed significantly more poorly to the control group, and statistically similar to each other) even after verbal IQ was controlled for. The authors suggest that a deficit in phonological awareness may be a key component to the cognitive phenotype seen in FASD.

Coffin, Baroody, Schneider, and O'Neill's (2005) biomarker research suggests that there may be a relationship between FASD and dyslexia. They were concerned with investigating whether or not eye-blink conditioning (EBC) is sensitive enough to pick up differences in conditioning styles in children with different developmental learning problems in which the cerebellum has been implicated (specifically dyslexia, attention deficit hyperactivity disorder (ADHD), and FAE). EBC is a Pavlovian paradigm used to study cerebellar-dependent memory and learning. It involves the momentary pairing of a neutral stimulus (the

conditioned stimulus, or CS; typically a true tone) with an aversive stimulus (the unconditioned stimulus, or US; typically a brief puff of air to the eye). This pairing reliably elicits a reflexive eyeblink response (the conditioned response, or CR) at the simple presentation of the CS. In the typical experimental paradigm there is a 650-ms delay from the onset of the 750-ms pure tone so that the puff of air occurs in the last 100-ms of the tone (Stanton & Freeman, 1994). The neural substrates of this standard short-delay conditioning are the cerebellum and related brainstem circuits.

Coffin et al. (2005) found that the EBC impairments in children with FAE were more similar to those of children with dyslexia than to those with ADHD. They hypothesized that (a) these differences in functional disturbances may explain why most children with FAE do not respond to ADHD medication, and (b) the attention deficits observed in FAE children may be due to underlying reading problems. The possibility that dyslexia may be part of the cognitive phenotype associated with FASD is important for the current research because, although conclusions cannot be drawn from patterns of cerebellar functioning only, it highlights the need for further behavioural assessments of reading abilities within this population.

From the literature reviewed above the characterisation of reading skill deficits in children with FASD would include; a lowered reading age in comparison to chronological age (Adnams, et al., 2007; Streissguth et al., 1991), naming speed deficits (Goldschmidt et al., 1996), comprehension difficulties (Sampson et al., 1997), which may be a result of IQ rather than alcohol exposure (Olsen et al., 1998), and phonological awareness difficulties (Adnams, et al., 2007). Further exploration of a broader range of cognitive skills involved in reading and reading ability is necessary with regards to children with FASD as reading skill deficits will further impact the already vulnerable academic performances of these children.

The Current Research

The current research is focused on assessing a broader range of cognitive skills involved in reading as well as reading ability in order to determine to what extent these deficits, if any, are prevalent within children with FASD. The measures used will assess the phonological and reading abilities of children who have been exposed to alcohol prenatally with those of non-exposed children from similar socioeconomic backgrounds. The current research is exploratory in nature and serves to inform further exploration of these cognitive skills within the large longitudinal cohort study.

The current study aims to review Adnams et al.'s (2007) findings of phonological awareness deficits in a different sample of children with FASD and to discern whether deficits in other measures of phonological abilities exist. The exploration of phonological skills in children with FASD is critical as this is the second known study worldwide to assess these skills. Such insight may help to inform and improve early diagnostic evaluations and intervention programmes aimed at improving cognitive abilities within this population.

Within the limited selection of literature focused on the relationship between reading abilities and FASD, three out of five articles focused on adolescent and adult samples. The current research is therefore important as it will add significant insight into the reading abilities of children with FASD. Due to the low literacy rates in South Africa (Venter, van Staden, & du Toit, 2006) and the results reported by Adnams et al. (2007) it is expected that the non-exposed children in this sample will perform quite poorly on the measures of reading ability in comparison to their chronological age, however the alcohol exposed children are expected to perform even more poorly than the non-exposed children.

Two of the five previous studies assessing reading ability in children with FASD used a computer-based programme (RSVP) to assess reading comprehension, memory and speed. The children participating in the current study come from disadvantaged communities and many would not have access to using computers. I am choosing to use the reading medium (paper) the children are used to in order to not disadvantage their performance abilities. Additionally, the reading test selected for use in the current study allows for a slightly more in-depth analysis of reading abilities as it assesses reading accuracy alongside speed and comprehension.

Of the five studies reviewed above that focused on reading abilities within FASD, four were conducted in the United States and one was conducted in South Africa. For South African researchers and clinicians, locally-based studies are essential because they allow one to estimate and explore the influence of our country's unique socioeconomic context on cognitive abilities within this population.

Hypotheses

In view of the exploratory nature of the study the primary hypotheses were general:

1. The exposed groups will perform more poorly than the non-exposed group on measures of phonological abilities.
2. The reading skills of the participants within the non-exposed groups will be worse than expected for their age on South African norms. The reading skills of the participants within the exposed group will be worse than that of the non-exposed children, however.
3. When level of prenatal alcohol exposure is assessed as a continuous variable there will be a linear relationship between the level of prenatal alcohol exposure and the participants' performances on tasks assessing phonological abilities and reading skills.

METHODS

Study Design

This study is cross-sectional in design. Comparisons are made between the performances of children with prenatal alcohol exposure and those without such exposure on tests assessing phonological and reading abilities. The two tests used are the Phonological Assessment Battery (PhAB; Frederickson, Frith, & Reason, 1997) and the Neale Analysis of Reading Ability (NARA; Neale, Whetton, Caspell, & McCulloch, 2005). The tests were administered in Afrikaans. I scored all tests, and was blind to the diagnostic of participants during both administration and scoring.

Participants

The participants involved in the current research were previously recruited for a pilot neuroimaging study. They were asked to return for further testing involving numerous tests including the current study's battery of reading and phonological ability tests. The 46 right-handed Afrikaans participants (20 boys and 26 girls) between the ages of 9 and 14 years of age were previously recruited from two similar socioeconomic sources; 22 were the older siblings of participants in the large longitudinal cohort study, and the other 24 were recruited and identified by a screening process in the Dietrich Moravian School in the Philippi farming area, where there is a very high incidence of alcohol abuse among local farm workers.

Retrospective interviews were conducted with the children's mothers regarding their alcohol consumption during pregnancy. A timeline follow-back approach was used to determine incidence and amount of drinking on a day-by-day basis during a typical 2-week period during pregnancy. Volume was recorded for each type of beverage consumed each day during the pregnancy and converted to ounces (oz) of absolute alcohol (AA). Any child whose mother who reported drinking at least 14 standard drinks per week (1.0 oz AA/day) on average or who reported engaging in binge drinking of more than four drinks per occasion (2.0 oz AA/drinking occasion) was considered heavily exposed. The majority (13 out of 14; 93%) of the control children's mothers abstained from drinking any alcohol during pregnancy, and none drank more than 0.05 oz AA/day on average or more than 1.00 oz AA on any single drinking occasion.

One of three expert dysmorphologists examined each child for growth and FAS dysmorphology (Jacobson et al., 2008). There was substantial agreement between the three examiners on the assessment of all dysmorphic features, particularly the three principal fetal alcohol-related features – philtrum and vermilion (measured using the Astley and Clarren (2001) rating scales) and palpebral fissure length (median interobserver r = .78). Of the 32 children whose mothers drank heavily during pregnancy, seven (22%) met the criteria for full FAS, three (9%) met the criteria for partial FAS (pFAS) and 22 (69%) did not meet the criteria for diagnosis of FAS/ pFAS but were still heavily exposed (and were thus classified as "other heavily exposed" (OHE)).

The exposed children constituted two groups; a FAS/pFAS group and an OHE group. The 14 children recruited as non-exposed controls came from the same socioeconomic environment as the exposed children and could be considered as representative of the general local population. Tests of hearing and visual abilities showed no sensory deficits in any of the children included in this study.

Measures and Instruments

Phonological Assessment Battery (PhAB)

The PhAB provides an assessment of a child's phonological skills in English and is used among South African clinicians for educational and neuropsychological purposes. This battery is comprised of six tests: alliteration, rhyme, spoonerisms, non-word reading, naming speed, and fluency (See Table 1 for details about the subtests and their scoring/ timing systems.). For the purpose of the current study the PhAB subtests were adapted and translated into Afrikaans by two research members in the larger cohort study. The original English test materials and the adapted and translated Afrikaans test materials of the PhAB subtests are included in Appendix A. Details of these appendices are given at the end of each subtest description below.

The PAELT used by Adnams et al. (2007) in their research focuses on six phonological awareness skills (rhyme, segmentation, blending, manipulation, letter knowledge and reading real and non-words). The PhAB test used within the current research focuses on three different aspects of phonological ability (i.e. phonological awareness, phonological production speed and phonological fluency, and includes one measure of non-phonological fluency). The appropriateness of the PhAB in assessing phonological awareness may be no

better or worse than the PAELT however it does shed more light on different aspects of verbal processing skills involved in phonological abilities.

Table 1. Battery of PhAB subtests administered

	PhAB tests	Subtests	Description	Number of items/ time limit
	Phonological awareness			
1	Alliteration tests	1a	Beginning sound (1 consonant)	5
		1b	Beginning sound (2 consonants)	5
2	Rhyme tests	2a	Phonologically similar	12
		2b	Phonologically dissimilar	9
3	Spoonerisms tests	3a	One word	10
		3b	Two words	10
4	Non-word reading tests	4a	One-syllable words	10
		4b	Two-syllable words	10
	Phonological processing speed			
5	Naming speed tests	5a	Picture	50
		5b	Digit	50
	Non-phonological fluency			
6	Fluency test	6a	Semantic	30 seconds
	Phonological fluency			
	Fluency tests	6b	Alliteration	30 seconds
		6c	Rhyme	30 seconds

The *alliteration test* is designed to assess a child's ability to identify the initial sounds of words. It comprises two parts, with each trial consisting of three words. The child is required to repeat back the two words with the same beginning sound (see Appendix A, Table A1).

The *rhyme test* is designed to test the child's ability to recognise the rhyme sound of single syllable words. The first part of the test consists of words that rhyme and have similar spelling, whereas the second part consists of rhyme words that are not necessarily spelt similarly. Each trial consists of three words. The child is required to repeat back the two words that end with the same sound (see Appendix A, Table A2).

The *spoonerisms test* is designed to identify whether a child is able to divide single syllable words and then blend them to form new words or word combinations. It also consists of two parts, both of which consist of verbal presentations of words to the child. In part one the child is presented with a word (e.g., *kat*) and a beginning letter sound (e.g., */v/*) and is required to replace the original beginning sound of the word with the new letter sound to create a new word (e.g., *kat* with a */v/* gives *vat*). This section consists of ten combinations of increasing difficulty, with one point being awarded for each correct trial. In part two the child is presented with two words (e.g., *vet man*) and is required to repeat the sequence but with the two beginning sound letters having been swopped around (e.g., *met van*). This section also consists of ten combinations of increasing difficulty; however, one point is now awarded for each correct word given (i.e., 2 points per trial are possible). For both parts the child is allowed to continue until he finishes the test or the time-limit of 3 minutes is reached (see Appendix A, Table A3).

The *non-word reading test* is used to explore any specific reading difficulties a child may have. It consists of one practice card and two test cards. For each of the test cards there are ten words which have been made up and have no meaning. These words are presented to the child and he/she is required to correctly read each word (see Appendix A, Table A4).

The *naming speed tests* are designed to test phonological production, involving retrieval of phonological coding at the whole word level. There are two naming speed subtests, *picture naming* and *digit naming*, with two trials for each. The time it takes to complete each trial is combined for each subtest to indicate the child's level of naming speed performance.

The *picture naming test* features a random sequence of five line drawn common objects which the child needs to name as quickly as possible (saying the words *bal*, *hoed*, *deur*, *tafel*, and *boks*). Each sequence contains 50 objects (see Appendix A, Figure A1). In the *digit naming test* the child is required to name each digit in a randomized 50-digit sequence. Only numerals 1 through 9 (excluding 7) are used (see Appendix A, Figure A2). There is no time limit for completion of either of these tasks; the child continues until all pictures or digits have been named (whether or not all items were named correctly). A maximum of two naming errors is allowed in each of the picture and digit naming tests. Children are allowed to correct themselves but more than two errors are to be noted in the scoring sheet.

The ability to correctly recall phonological information from long-term memory is assessed by the *fluency test*. This test is comprised of three subtests: semantic, alliteration, and rhyme. In each subtest the child has 30 seconds in which he is required to present words that belong to the same semantic category (e.g., *things in your school*), or words with the same beginning letter sound (e.g., *words beginning with /k/*), or words rhyming with the presented word (e.g., *words rhyming with bad*). For each subtest there is one practice section and two testing sections. Each word presented matching the required instruction for each subtest carries a one point score. Subtotals are calculated for each of the two testing sections to create independent fluency scores for the semantic, alliteration and rhyme subtests (see Appendix A, Table A5).

Neale Analysis of Reading Ability (NARA)

This assessment instrument consists of two parallel forms, each containing six passages of text of gradually increasing difficulty. The test measures reading speed, accuracy, and comprehension and expresses a score in each of those domains in terms of an age equivalent score. For the purpose of the current research a translated Afrikaans version by Bower and Hartman (2006) of the original NARA (Neale, et al., 2005) will be used. This version is utilised by some South African clinicians for educational and neuropsychological testing of Afrikaans children between the ages of 6 and 13. Accuracy and speed of reading are recorded while the child is reading the passage. Accuracy is measured by the number of reading errors the child makes while reading the passage. An error can fall into one of six categories: mispronunciations, substitutions, refusals, additions, omissions, and reversals. Mispronunciations are recorded when phonetic errors are made; in the case of the current administration, non-Afrikaans pronunciation errors were not recorded because of the different Afrikaans dialects within the sample population. Substitutions are recorded when real words are used instead of words present in the passage. Refusals are recorded when the child pauses over a word for 4-to-6 seconds and is unable to attempt the word. Addition errors are recorded when words or parts of words are inserted into the passage. Omissions are recorded when words are omitted from the text. Reversal errors are recorded when the letters of words are swopped around (April, 2002).

There are a maximum number of errors the child is allowed to make on each passage; passages one through five have a maximum of 16 errors, and 20 errors is the maximum allowed on the sixth passage. Once a child has exceeded this number the testing session is ended. For scoring purposes the performance of the child on each passage is included if the

errors are less than or equivalent to the maximum permissible errors for that passage. If the maximum is exceeded the child's scores for accuracy, speed and comprehension will only constitute those passages completed before the passage on which he/she failed (April, 2002).

For each of the six reading levels the child's speed of reading is measured by the length of time it takes to complete each passage; no time limit exists. The average reading speed is calculated by totalling the length of time taken for each passage successfully completed and dividing that score by the total number of words within those passages. This number is then multiplied by 60 to produce the average reading speed (April, 2002).

Comprehension ability is measured by asking the child a series of questions pertaining to the passage he has just completed reading. The first passage has four questions, whereas passages two through six each have eight questions. The total comprehension score is calculated by adding all correct scores together for those passages that were successfully completed (April, 2002). See Figure 1 for the NARA recording schedule.

		RATE	ACCURACY				COMPREHENSION
Passage	No. of words	Time in secs.	Max. score	- (minus)	No. of errors	= Accuracy score	No. of correct answers
Level 1 *Bird*	[25]			-		=	
Level 2 *Flip and Ansie*	[54]			-		=	
Level 3 *Gert*	[80]			-		=	
Level 4 *Haunted house*	[102]			-		=	
Level 5 *Scuba divers*	[126]			-		=	
Level 6 *Volcano*	[137]			-		=	
Total # words	[ ]	[ ]	← Total time				
Total Raw Score			← [Total number of words/ total time] x 60				
Standardised Scores Reading age							

Figure 1. NARA recording schedule

Procedure

Approval for all recruitment and experimental procedures was obtained from the University of Cape Town's Faculty of Health Science Research Ethics Committee. Prior to beginning any study procedures, informed consent was obtained from the mothers/ primary caregivers and assent was obtained from the children (see Appendix B). All testing appointments were scheduled by the project secretary and the children and their mothers/caregivers were driven to the larger study's research unit at the University of Cape Town's Faculty of Health Science' Child Development Laboratory by the project driver. As noted above, I was unaware of the child's clinical diagnosis and whether he/she had been exposed to alcohol prenatally or not. Each child was tested in a room featuring a desk and two chairs, and the layout of the testing relationship was the same for all participants (see Figure 2). The children were administered the NARA first; after a 5-minute break, the PhAB was administered. Each testing session took between 40 and 90 minutes to complete depending on the level of the child's performance (i.e., children who performed well on the tests and were able to go further took a longer time to complete the tests than a child who struggled with the material). Mothers received R50 compensation for participating and the children received a small gift (for example a box of smarties) including lunch.

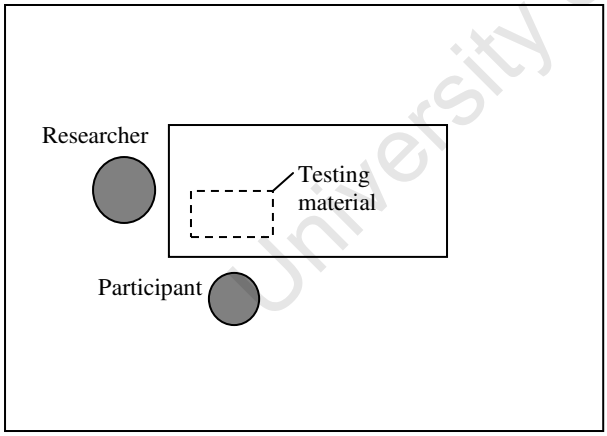

Figure 2. Layout of testing relationship

Data Analysis

PhAB raw scores were used for analysis as no South African norms exist. It is assumed that different groups of tests within the PhAB assess different areas of phonological development (Frederickson, et al., 1997). In order to simplify the data analyses and the qualitative interpretation of the results, scores from the nine PhAB subtests were grouped into four performance measures representing the different areas of phonological development:

phonological awareness (alliteration, rhyme, spoonerisms, and non-words), *phonological production speed* (picture and digit naming speed), *phonological fluency* (alliteration, and rhyme fluency) and *non-phonological fluency* (semantic fluency) (Frederickson et al., 1997). With regard to the NARA, standardised scores based on South African norms published by Bower and Hartman (2006), were derived and used in the final data analysis. Hence, the final data analyses were conducted on seven outcome variables (PhAB: *phonological awareness*, *phonological production speed*, *phonological fluency* and *non-phonological fluency*; NARA: *rate*, *accuracy*, and *comprehension*). Descriptions for the PhAB performance measures are described in Table 2.

Table 2. Descriptions for the PhAB performance measures

Outcome variables	Description
PhAB subtests[a]	
Phonological awareness	Based on four test scores (alliteration, rhyme, spoonerisms and non-word reading) this measure represents a score closest to actual reading and spelling ability and is most likely to be influenced by grapheme-phoneme knowledge
Phonological production speed	Based on the scores two naming speed subtests (picture and digit) this measure represents the child's fast and automatic retrieval of phonological coding at the whole word level
Phonological fluency	Based on the scores from two fluency subtests (alliteration and rhyme) this measure represents the child's ability to retrieve phonological codes based on alliteration and rhyme from memory
Non-phonological fluency	Based on the score from the semantic fluency subtest, this non-phonological measure of fluency enables one to make comparisons between the child's ability to retrieve from memory phonological codes with that of non-phonological codes

Note. PhAB = Phonological Assessment Battery

[a]Descriptions taken from Frederickson, et al. (1997).

The Statistical Package for the Social Sciences (SPSS, 2008) was used to analyze the data. Due to the exploratory nature of the study, three different modes of analysis were used to

interpret the data. First, independent samples *t*-tests were used to determine whether exposure to prenatal alcohol affected performance on the PhAB performance measures and the NARA age equivalent scores (exposed versus non-exposed). Previous research informed some directions of expected relationships for these analyses. The exposed group was expected to perform better on measures assessing phonological abilities and reading skills than the exposed group, therefore one-tailed p-values were used for the PhAB phonological performance measures and all three NARA age equivalent scores. No *a priori* relationship direction was expected for the PhAB non-phonological fluency measure and therefore a two-tailed p-value was used.

Second, analyses of covariance (ANCOVAs) were used to determine whether between-group effects based on the participant's dysmorphological diagnoses, existed. Factors associated with prenatal alcohol exposure (dose, duration and timing) can have different effects on the developing fetus's facial phenotype and their cognitive and behavioural profile. Dysmorphological diagnoses help to determine which children have been the most severely affected by the teterogenic effects of prenatal alcohol exposure (FAS and pFAS) to those considered less severely affected (FAE). Three independent diagnostic groups were formed for the ANCOVAs: the first group included all children diagnosed with fetal alcohol syndrome oe partial fetal alcohol syndrome (FAS/pFAS), the second group included all other heavily exposed children who did not meet the criteria for a diagnosis of FAS or pFAS (OHE) and the third group included all children who were not exposed to alcohol prenatally (Control). Selected covariates were entered into the ANCOVAs to determine their influence on the particular outcome variable in question. These will be discussed in more detail in the predictor variables section.

Finally, multiple regression analyses were used to determine whether the children's levels of exposure to prenatal alcohol (*alcohol*) would affect their PhAB and NARA performances. The relationships between *alcohol* and the outcome variables (PhAB performance measures and NARA age equivalent results) were assessed after selected predictor variables had been entered into the multiple regression analyses. Kolmogorov-Smirnov test results showed the normality distribution of *alcohol* as well as of each selected predictor variable. Bivariate correlation matrices (Pearson's and Spearman's) illustrated the relationship between each outcome variable, *alcohol* and the predictor variables selected for entry into each multiple regression analyses. For all multiple regression analyses *alcohol* was entered as a single

predictor variable into the first model, as the contribution of alcohol in predicting the outcome variables are the results of interest. Predictor variables were entered all together into the second model of the analysis to determine their influence on the particular outcome variable in question. Cohen's (1992) rule of thumb for effect size interpretations was used for between-group comparisons: r = .10 (small effect), r = .30 (medium effect), and r = .50 (large effect).

The data from 46 participants were used in both the independent *t*-tests and the GLM-based analyses. In the multiple regression analyses, however, the data from only 42 participants was used (the reason for this discrepancy is given below). The independent variable of interest in the multiple regression analyses was *alcohol*. The measure of this variable was defined as the recorded measure of 1.0 oz of AA per day across pregnancy (AA/day). This self-reported measure was determined as part of a maternal screening interview which was conducted when the participants were recruited for the previous pilot study. Data from this interview were missing for four participants: The screening interview for one child was unavailable and three screening interviews were completed by the grandmothers because the mothers could not attend the session.

Predictor variables

ANCOVAs. For the PhAB performance measures, *IQ* was entered as a covariate in order to determine the relationship between diagnostic group (i.e. members in the FAS/pFAS, OHE and Control groups) and the outcome variables after the effects of IQ had been considered. For the NARA age equivalent scores *IQ* and the three PhAB phonological performance measures (*phonological awareness*, *phonological production speed*, and *phonological fluency*) were entered as covariates to determine the relationship between diagnostic group and the outcome variables after the effects of *IQ* and phonological abilities had been considered.

Multiple regression-based analyses. For the PhAB performance measures, *IQ* was selected as a predictor variable for consideration as a potential confounder of the relation between *alcohol* and performance on the outcome variables. For the NARA age equivalent scores: *IQ* and the three PhAB phonological performance measures were selected as predictor variables for consideration as potential confounders of the relation between *alcohol* and performance on the outcome variables.

The fourth PhAB non-phonological performance measure was not included in the analyses as it serves as a comparative measure to the PhAB phonological fluency performance measure only and not as a predictor to reading ability. There is an established relationship within the literature between phonological abilities and performance on reading tests (Stahl & Murray, 1994). In order to determine whether there are between-group differences for the diagnostic groups in reading skills, the influence phonological abilities has in predicting these outcomes variables needs to be considered. An estimate of *IQ* was constructed to determine the mediating effects of *IQ* on outcome performances. *IQ* was based on Sattler's (1992) formula for Short Form IQ, using seven subtests from the Wechsler Intelligence Scale for Children - Third Edition (WISC-III; Weschler, 1991) – Similarities, Arithmetic, Digit Span, Symbol Search, Coding, Block Design, and Picture Completion – and one subtest from the Wechsler Intelligence Scale for Children - Fourth Edition (WISC-IV; Weschler, 2003) – Matrix Reasoning. Validity coefficients for the Sattler Short Form based on five or more subtests is reported to consistently exceed $r = .90$ (Sattler, 1992). The *IQ* data were all collected prior to the current study as part of the first pilot study.

RESULTS

Comparison of the Exposed versus Non-exposed Groups

Participant Characteristics

The current analyses were based on the data of 46 participants. Table 3 shows participant characteristics across the exposed and non-exposed (two study groups) for the variables *age*, *alcohol* and *IQ*. Independent *t*-test results showed that the participants in the exposed group were similar, on average, in age to the participants in the non-exposed group ($t(44) = .87$, $p = .390$), but, as expected, participants in the exposed group had lower IQ scores on average than participants in the non-exposed group ($t(44) = -2.39$, p(one-tailed) = .011). The distribution of the alcohol data was non-normal, $D(42) = .17$, $p < .05$, therefore a Mann-Whitney test was performed. Results from this test showed, as expected, that the participants in the exposed group ($Mdn = 1.37$) were exposed to significantly more alcohol, on average, than the participants in the non-exposed group ($Mdn = 0.00$), $U = 8.00$, p(one-tailed) = .0000000004, $r = .79$.

Table 3. Demographic and clinical characteristics of participants in the two study groups

	Group	
Variable	Exposed $n = 32$	Non-exposed $n = 14$
Age[a]	11.45 (1.30)	11.11 (1.14)
Alcohol[b]	2.26 (1.76)[c]	0.00 (0.01)
IQ	64.72 (10.62)	73.17 (11.90)

Note. For each continuous variable means are presented with standard deviations in parentheses.
[a]Age = chronological age expressed in years.
[b]Alcohol expressed as AA/day.
[c]Data based on 28 participants.

Before the analyses could be conducted, descriptive statistics and characteristics of the distributions of the outcome variables, for the exposed and the non-exposed groups were examined. With regards to distributions of the PhAB performance measures; two outliers were found within the distribution of the *phonological production speed* performance measures; one in the exposed group and one in the non-exposed group (see Appendix C, Figure C1). One outlier was found within the distribution of the *non-phonological fluency*

performance measures in the non-exposed group (see Appendix C, Figure C2). With regard to distributions of the NARA age equivalent scores; one outlier was found within the NARA rate age equivalent scores in the non-exposed group (see Appendix C, Figure C3). None of the outliers identified were due to recording or data entry errors; they were representative of the participants' level of performances. At the same time, however, they were not representative of the performances of the sample as a whole, and so had the potential to bias subsequent statistical models. In order to control for these outliers the scores were changed to the value equivalent to two standard deviations of the mean for their respective measure (Field, 2005). Descriptive statistics for the PhAB performance measures and the NARA age equivalent scores can be seen in Table 4.

Determining the relationship between the two study groups and PhAB performance measures

Statistical analyses were performed on the four composite PhAB performance measures (*phonological awareness*, *phonological production speed*, *phonological fluency* and *non-phonological fluency*). No statistically significant between-group differences were found on any of the performance measures; each of these analyses is discussed individually below.

PhAB phonological awareness. The distribution of the PhAB phonological awareness performance measures met the assumptions for independence, homogeneity of variance ($F(1,44) = 0.90$, $p > .05$), and normality for the exposed ($D(32) = .14$, $p > .05$), and non-exposed ($D(14) = .10$, $p > .05$) groups. The exposed group performed more poorly than the non-exposed group; however independent *t*-test results showed, unexpectedly, that no statistically significant between-group difference existed for this measure.

PhAB phonological production speed. The distribution for the PhAB phonological production speed performance measures met the assumptions for independence, homogeneity of variance ($F(1,44) = 0.90$, $p > .05$), and normality for the exposed ($D(32) = .15$, $p > .05$) and non-exposed ($D(14) = .20$, $p > .05$) groups. The exposed group performed more poorly than the non-exposed group; however independent *t*-test results showed, unexpectedly, that no statistically significant between-group difference existed for this measure.

PhAB phonological fluency. The distribution of the PhAB phonological fluency performance measures met the assumptions for independence, homogeneity of variance ($F(1,44) = 2.66$, $p > .05$) and normality for the exposed ($D(32) = .11$, $p > .05$), and non-exposed ($D(14) = .18$, p

> .05) groups. The exposed group performed slightly better than the non-exposed group; however independent *t*-test results showed that no statistically significant between-group difference existed for this measure.

Table 4. Descriptive statistics for the PhAB performance measures (two study groups)

Outcome measure	Exposed *n* = 32	Non-exposed *n* = 14	Test statistic	*p*	ESE (*r*)
PhAB					
Phonological awareness	13.50 (4.83)	14.00 (3.92)	0.34	.135	.05
Alliteration	8.13 (2.55)	8.71 (1.54)			
Rhyme	15.13 (5.92)	14.86 (4.91)			
Spoonerisms	13.44 (8.99)	14.86 (7.40)			
Non-word reading	16.91 (3.74)	17.36 (4.01)			
Phonological production speed	91.47 (24.30)	87.00 (24.19)	-0.55	.284	.09
Picture naming	112.19 (28.66)	105.14 (26.54)			
Digit naming	71.25 (30.66)	69.43 (24.91)			
Phonological fluency	9.06 (3.32)	8.93 (2.27)	0.14	.446	.02
Alliteration	11.22 (4.15)	11.21 (3.19)			
Rhyme	6.44 (3.77)	6.29 (3.02)			
Non-phonological fluency	16.78 (4.31)	16.07 (3.58)	0.54	.592[b]	.08
NARA[a]					
Rate	7.70 (1.26)	7.24 (1.47)	169.50	.099	.19
Accuracy	9.47 (1.97)	9.03 (2.17)	169.50	.275	.09
Comprehension	8.84 (1.37)	8.36 (1.57)	184.00	.173	.14

Note. For each subtest's data, means are presented with standard deviations in parentheses. For each *t*-test, *df* = 44. ESE = effect size estimate. The test statistics presented for PhAB outcome measures is *t*; for NARA outcome measures is Mann-Whitney *U*.
PhAB = Phonological Assessment Battery; NARA = Neale Analysis of Reading Abilities.
[a]Scores presented for this test are reading age equivalents.
[b]*p*-value = two-tailed.

PhAB non-phonological fluency. The distribution for the PhAB non-phonological fluency performance measures met the assumptions for independence, homogeneity of variance ($F(1,44) = 0.07$, $p > .05$), and normality for the exposed ($D(32) = .10$, $p > .05$) and the non-exposed group ($D(14) = .22$, $p > .05$) groups. The exposed group performed slightly better

than the non-exposed group; however independent *t*-test results showed, unexpectedly, that no statistically significant between-group difference existed for this measure.

In the PhAB test battery, the non-phonological performance measure serves as a comparative measure to the phonological fluency performance measure in order to discern if there is a difference between the participants' abilities to generate words from memory based on semantic association and their abilities to generate words based on phonological association. This was done using non parametric Wilcoxon tests. For the exposed group, phonological fluency scores (*Mdn* = 9.00) were significantly lower than non-phonological fluency scores (*Mdn* = 17.00), $T = 1.5$, $p = .000000003$, $r = -.60$. Similarly for the non-exposed group, phonological fluency scores (*Mdn* = 8.50) were significantly lower than non-phonological fluency scores (*Mdn* = 15.00), $T = 0$, $p = .0001$, $r = -.63$. These findings suggest that participants in both groups struggle more with generating words associated phonologically than with words associated semantically.

Determining the relationship between the two study groups and NARA age equivalent scores

Statistical analyses were performed on the three NARA age equivalent scores (*rate*, *accuracy* and *comprehension*). Each of these analyses is discussed individually below. No statistically significant between-group differences were found on any of the age equivalent scores; each of these analyses is discussed individually below.

NARA rate. The distribution of the NARA rate age equivalent scores met the assumptions for independence, homogeneity of variance ($F(1,44) = 1.27$, $p > .05$), and normality for the non-exposed group ($D(14) = .18$, $p > .05$). The assumption of distribution normality was not met for the exposed group, however ($D(32) = .25$, $p < .05$). Although several transformations were attempted, the distribution of these data remained non-normal, and as a result a Mann-Whitney test was performed. Results from this test showed that the participants' reading rate age equivalent scores in the exposed group (*Mdn* = 7.04) were, on average, lower than the participants in the non-exposed group (*Mdn* = 7.57). This difference approached statistical significance; however the size of the effect was small.

NARA accuracy. The distribution of the NARA accuracy age equivalent scores met the assumptions for independence, homogeneity of variance ($F(1,44) = 1.37$, $p > .05$) , and normality for the non-exposed group ($D(14) = .15$, $p > .05$). The assumption of distribution

normality was not met for the exposed group, however ($D(32) = .20$, $p < .05$). Although several transformations were attempted, the distribution of these data remained non-normal, and as a result a Mann-Whitney test was performed on the data. Results from this test showed, as expected, that the reading accuracy age equivalent scores for the participants' in the exposed group (*Mdn* = 8.08) were, on average, lower than the participants in the non-exposed group (*Mdn* = 9.07). Surprisingly this difference was not statistically significant; however the size of the effect was small.

NARA comprehension. The distribution of the NARA comprehension age equivalent scores met the assumptions for independence, homogeneity of variance ($F(1,44) = 0.72$, $p > .05$) , and normality for the non-exposed group ($D(14) = .16$, $p > .05$). The assumption of distribution normality was not met for the exposed group, however ($D(32) = .16$, $p < .05$). Although several transformations were attempted, the distribution of these data remained non-normal, and as a result a Mann-Whitney test was performed on the data. Results from this test showed that the reading comprehension age equivalent scores for the participants' in the exposed group (*Mdn* = 8.55) were, on average, lower than the participants in the non-exposed group (*Mdn* = 9.03). Surprisingly this difference was not statistically significant; however the size of the effect was small.

Wilcoxon tests were performed in order to determine whether participants in this study have reading abilities below their chronological ages. The non-exposed participants performed below their chronological age (Mdn = 10.85), as expected, for all three NARA reading age equivalent scores; rate (*Mdn* = 7.57), $T = 0$, p(one-tailed) = .00005, $r = .62$, accuracy (*Mdn* = 9.07), $T = 12$, p(one-tailed) = .00005, $r = .48$, and comprehension (*Mdn* = 9.03), $T = 1$, p(one-tailed) = .00005, $r = .61$. The exposed participants also performed below their chronological age (Mdn = 11.37), as expected, for all three NARA reading age equivalent scores; rate (*Mdn* = 7.04), $T = 0$, p(one-tailed) = .00000000001, $r = .66$, accuracy (*Mdn* = 8.08), $T = 20$, p = .00000005, $r = .63$, and comprehension (*Mdn* = 8.55), $T = 0$, p(one-tailed) = .00000000001, r = .66. Even though the non-exposed and exposed participants are performing below their chronological ages, findings from the Mann-Whitney tests suggest that there is only an approach towards a statistically significant between-group difference for NARA rate and no statistically significant between-group difference for NARA accuracy and comprehension. In other words the two study groups are performing similarly poorly, on average, for all three reading ability measures.

Comparison of the FAS/pFAS, OHE and Control Groups

Participant Characteristics

The current analyses were based on the data for 46 participants. Table 5 shows participant characteristics across the FAS/pFAS, OHE and Control groups (diagnostic group) for the variables *age*, *alcohol* and *IQ*. One-way ANOVA results showed no statistically significant between-group differences for age ($F(2,45) = .35$, $p = .706$), and unexpectedly no statistically significant between-group differences for IQ ($F(2,45) = 1.55$, $p = .223$). The distribution of the alcohol data was non-normal for all three diagnostic groups, FAS/pFAS $D(9) = .33$, $p < .05$, OHE $D(19) = .22$, $p < .05$, and Control $D(14) = .53$, $p < .05$, therefore a Kruskal-Wallis test was performed. Results from this test showed, as expected, that between-group differences existed for level of prenatal alcohol exposure, $H(2) = 28.38$, $p = .000001$. Mann-Whitney tests were used to follow up this finding. A Bonferroni correction was applied and so all effects are reported at a .0167 level of significance. Level of prenatal alcohol exposure for the FAS/pFAS group ($Mdn = 2.17$) was, as expected, significantly higher than for the Control group ($Mdn = 0.00$), $U = 0.00$, $p = .00001$, $r = .92$. Level of prenatal alcohol exposure for the OHE group ($Mdn = 1.81$) was, as expected, also significantly higher than for the Control group, $U = 0.00$, $p = .000000001$, $r = .87$. Unexpectedly, level of prenatal alcohol exposure for the FAS/pFAS group was not significantly higher than for the OHE group, $U = 73.00$, $p = .277$, however the effect seen was small, $r = .12$.

Table 5. Demographic and clinical characteristics of the three group study

Variable	FAS/ pFAS *n* = 10	OHE *n* = 20	Control *n* = 14
Age[a]	11.23 (1.47)	11.51 (1.25)	11.18 (1.16)
Alcohol[b]	2.82 (2.65)[c]	2.40 (2.54)[d]	0.00 (0.00)
IQ	62.74 (12.85)	66.97 (10.22)	71.05 (12.24)

Note. Means are presented, with standard deviations in parentheses.
[a]Age = chronological age expressed in years.
[b]Alcohol expressed as AA/day.
[c]Data based on 9 participants.
[d]Data based on 19 participants.

ANCOVAs were performed to determine whether differences in diagnostic group contributed to performance differences on the PhAB and NARA outcome measures. For these analyses

diagnostic group was treated as the fixed (independent) variable, and selected predictor variables, which will be discussed within each ANCOVA analysis, were treated as covariates.

Before the analyses could be conducted, descriptive statistics and characteristics of the distributions of the variables, for each of the three diagnostic groups, were examined. Boxplots were constructed to determine if any outliers existed in the distributions of the PhAB performance measures, NARA age equivalent scores and *IQ*. With regard to the PhAB performance measures: three outliers were found within the distribution of the *phonological production speed* performance measures only; two within the OHE group and one in the Control group (see Appendix D, Figure D1). With regard to the NARA age equivalent scores: only outlier was found within the distribution of *rate* reading age equivalent scores within the OHE group (see Appendix D, Figure D2). No outliers were found with regard to the IQ scores (see Appendix D, Figure D3). None of the outliers identified were due to recording or data entry errors; they were representative of the participants' levels of performances. At the same time, however, they were not representative of the performances of the sample as a whole, and so had the potential to bias subsequent statistical models. In order to control for these outliers the scores were changed to the value equivalent to two standard deviations of the mean for their respective measure (Field, 2005). Descriptive statistics for the PhAB performance measures and the NARA age equivalent scores can be seen in Table 6. The analyses for the PhAB performance measures will be discussed first; the analyses for the NARA reading age equivalent scores will be discussed after that.

Determining the relationship between diagnostic group and PhAB performance measures

ANCOVAs were performed to determine a) if there statistically significant between-group differences on each of the PhAB performance measures and b) how the covariate *IQ* might have influenced this relationship. In other words, if a significant relationship is found between diagnostic group and PhAB performance measures it is necessary to determine whether this relationship exists after the effect of *IQ* has been considered.

Table 6. Descriptive statistics for PhAB performance measures and NARA age equivalent scores (diagnostic group)

	Diagnostic group		
	FAS/ pFAS	OHE	Control
Outcome variable	*n* = 10	*n* = 22	*n* = 14
PhAB			
Phonological awareness	11.30 (6.27)	14.64 (3.74)	13.79 (4.06)
Alliteration	6.70 (3.80)	8.77 (1.41)	8.71 (1.54)
Rhyme	11.80 (6.76)	16.64 (4.94)	14.86 (4.91)
Spoonerisms	10.40 (10.18)	15.27 (8.17)	14.14 (7.55)
Non-word reading	15.80 (5.45)	17.41 (3.43)	17.36 (3.27)
Phonological production speed	104.30 (29.55)	90.05 (32.01)	92.43 (30.17)
Picture naming	123.30 (28.17)	103.41 (22.54)	112.57 (36.71)
Digit naming	93.60 (78.19)	63.68 (18.69)	72.64 (26.54)
Phonological fluency	7.90 (3.54)	9.68 (3.14)	8.79 (2.26)
Alliteration	9.80 (3.52)	11.95 (4.17)	11.00 (3.23)
Rhyme	5.40 (4.25)	6.05 (3.54)	6.21 (2.99)
Non-phonological fluency	14.70 (6.60)	18.00 (3.53)	16.64 (3.86)
NARA[a]			
Rate	7.16 (1.54)	7.51 (1.61)	7.63 (1.34)
Accuracy	8.86 (2.26)	9.19 (2.13)	9.34 (2.07)
Comprehension	7.91 (1.52)	8.65 (1.55)	8.70 (1.45)

Note. Means are presented with standard deviations in parentheses. FAS/pFAS = fetal alcohol syndrome or partial fetal alcohol syndrome diagnosis; OHE = Other heavily exposed; Control = non-exposed. PhAB = Phonological Assessment Battery.
[a]Scores presented for this test are age equivalents.

PhAB phonological awareness. The distribution of the PhAB phonological awareness performance measures met the assumptions for independence, homogeneity of variance ($F(2,43) = 1.90$, $p > .05$), and normality for the FAS/pFAS ($D(10) = .12$, $p > .05$), OHE ($D(22) = .15$, $p > .05$), and Control ($D(14) = .12$, $p > .05$) groups. ANCOVA revealed that the covariate, *IQ*, was significantly related to the outcome variable, $F(1,42) = 19.82$, $p = .0001$, $r = .56$, and that there was no statistically significant main effect of diagnostic group on this measure after considering the effect of *IQ*, $F(2,42) = 1.77$, $p = .182$, partial $\eta^2 = .08$.

PhAB phonological production speed. The distribution of the PhAB phonological production speed performance measures met the assumptions for independence, homogeneity of variance ($F(2,43) = 0.04$, $p > .05$), and normality for the FAS/pFAS ($D(10) = .29$, $p > .05$), and Control ($D(14) = .18$, $p > .05$) groups. The assumption of distribution normality was not met for the OHE group, however ($D(22) = .21$, $p < .05$). Although several transformations were attempted, the distribution of these data remained non-normal. Results from a Kruskal-Wallis test showed that statistically significant between-group differences did not exist for diagnostic group, $H(2) = 2.51$, $p = .286$.

PhAB phonological fluency. The distribution of the PhAB phonological fluency performance measures met the assumptions for independence, homogeneity of variance ($F(2,43) = 1.93$, $p > .05$), and normality for the FAS/pFAS ($D(10) = .22$, $p > .05$), OHE ($D(22) = .13$, $p > .05$), and Control ($D(14) = .21$, $p > .05$) groups. ANCOVA revealed that the covariate, *IQ*, was significantly related to the performance measure, $F(1,42) = 8.79$, $p = .005$, $r = .41$, and that there was no statistically significant main effect of diagnostic group on this measure after considering the effect of *IQ*, $F(2,42) = 1.34$, $p = .273$, partial $\eta^2 = .06$.

PhAB non-phonological fluency. The distribution of the PhAB non-phonological fluency performance measures met the assumptions for independence, homogeneity of variance ($F(2,43) = 2.50$, $p > .05$), and normality for the OHE ($D(22) = .16$, $p > .05$) and Control ($D(14) = .23$, $p > .05$) groups. The assumption of distribution normality was not met for the FAS/pFAS group, however ($D(10) = .22$, $p < .05$). These data were square root transformed and their distribution met the assumption of normality for the FAS/pFAS ($D(10) = .21$, $p > .05$), OHE ($D(22) = .14$, $p > .05$) and Control ($D(14) = .19$, $p > .05$) groups. ANCOVA revealed that the covariate, *IQ*, was not significantly related to the performance measure, $F(1,42) = 0.02$, $p = .902$, $r = .02$, but that there was a statistically significant main effect of diagnostic group on this measure after considering the effect of *IQ*, $F(2,42) = 6.16$, $p = .004$, partial $\eta^2 = .23$. Planned contrasts revealed that the performances of participants in the FAS/pFAS group were statistically lower than participants in the OHE group but not statistically lower than participants in the Control group, $t(44) = -2.08$, p(one-tailed) $= .022$, $r = .30$ and $t(44) = 1.04$, p(one-tailed) $= .153$, $r = .15$.

The findings from these analyses show no statistically significant between-group differences on the PhAB phonological performance measures after the effect of *IQ* was considered. A

statistically significant between-group difference did exist between the FAS/pFAS and OHE groups on the PhAB non-phonological fluency performance measure. More specifically, the FAS/pFAS group produced, on average, less semantically associated words than the OHE group. This same effect was not seen between the FAS/pFAS and Control groups, however.

Determining the relationship between diagnostic group and NARA age equivalent scores

ANOVAs were performed to determine a) if there statistically significant between-group differences on each of the NARA performance measures and b) how the covariate *IQ,* as well as performance on the three phonological subtests of the PhAB (*phonological awareness*, *phonological production speed* and *phonological fluency*) might have influenced this relationship.[1] In other words, if a significant relationship is found between diagnostic group and the NARA reading age equivalent scores it is necessary to determine whether this relationship exists after the effects of *IQ* and phonological abilities have been considered.

NARA rate. The distribution of the NARA rate age equivalent scores met the assumptions for independence, homogeneity of variance ($F(2,43) = 0.24$, $p > .05$), and normality for the Control group ($D(14) = .16$, $p > .05$). The assumption of distribution normality was not met for the FAS/pFAS and OHE groups, however ($D(10) = .35$, $p < .05$) and ($D(22) = .23$, $p < .05$) respectively. Although several transformations were attempted, the distribution of these data remained non-normal. Results from a Kruskal-Wallis test showed that statistically significant between-group differences did not exist for diagnostic group, $H(2) = 1.14$, $p = .565$.

NARA accuracy. The distribution of the NARA rate age equivalent scores met the assumptions for independence, homogeneity of variance ($F(2,43) = 0.25$, $p > .05$), and normality for the FAS/pFAS ($D(10) = .20$, $p > .05$) and the Control ($D(14) = .15$, $p > .05$) groups. The assumption of distribution normality was not met for the OHE group, however ($D(22) = .20$, $p < .05$). Although several transformations were attempted, the distribution of

[1] The fourth PhAB performance measure, *non-phonological fluency,* was not included in these multiple regression analyses as it serves as a comparative measure to the *PhAB phonological fluency* performance measure only and not as a predictor of reading ability (Frederickson, et al., 1997).

these data remained non-normal. Results from a Kruskal-Wallis test showed that statistically significant between-group differences did not exist for diagnostic group, $H(2) = 0.32$, $p = .851$.

NARA comprehension. The distribution of the NARA comprehension age equivalent scores met the assumptions for independence, homogeneity of variance ($F(2,43) = 1.90$, $p > .05$) and normality for the FAS/pFAS ($D(10) = .27$, $p > .05$), OHE ($D(22) = .14$, $p > .05$) and Control ($D(14) = .18$, $p > .05$) groups. ANCOVA revealed that the covariate, *phonological awareness*, was significantly related to the outcome variable, $F(1,39) = 8.91$, $p = .005$, r = .41. The remaining covariates, *IQ* ($F(1,39) = 1,43$, $p = .239$, $r = .19$), *phonological production speed* ($F(1,39) = 1.59$, $p = .215$, $r = .20$), and *phonological fluency* ($F(1,39) = 0.02$, $p = .879$, $r = .02$) were not significantly related to the outcome variable. There was no statistically significant main effect of diagnostic group on this measure after controlling for the effects of *IQ* and the three PhAB measures, $F(2, 39) = 0.26$, $p = .774$, partial $\eta^2 = .01$.

The findings from these analyses show no statistically significant between-group differences on the NARA age equivalent scores after the effect of *IQ* was considered.

Regression-Based Statistical Analyses

For this analysis, exposure to alcohol was treated as a continuous variable. This approach stands in contrast to the first two analyses, where exposure to alcohol was treated as a categorical variable (exposed vs. non-exposed or FAS/pFAS vs. OHE vs. Control). Taking the approach of treating exposure to alcohol as a continuous variable was followed to determine whether there is a relationship between level of prenatal alcohol exposure (AA/day; *alcohol*) and the PhAB performance measures or the NARA age equivalent scores rather than between these outcome measures and either exposure versus non-exposure or a diagnostic relationship. For these analyses *alcohol* was treated as the primary predictor variable and as a result was entered individually into each of the first models in the multiple regression analyses. All potential predictor variables were entered simultaneously into the second models of the regression analyses to determine their influence on the particular outcome variable in question. The current analyses were based on the data of 42 participants.

Boxplots were constructed to determine if any outliers existed in the distributions of the PhAB performance measures, NARA age equivalent scores, *alcohol*, and *IQ*. With regard to

the PhAB performance measures: within the scores on the *phonological awareness* and measure one outlier was found, within the scores on the *phonological production speed* measure two outliers were found, within the scores on the *phonological fluency* measure no outliers were found and within the scores on the *non-phonological fluency* measure one outlier was found (see Appendix E, Figure E1). None of the outliers identified were due to recording or data entry errors; they were representative of the children's level of performances. At the same time, however, they were not representative of the performances of the sample as a whole, and so had the potential to bias subsequent statistical models. In order to control for these outliers the scores were changed to the value equivalent to two standard deviations of the mean for their respective measure (Field, 2005). With regard to the NARA reading age equivalent scores (*rate*, *accuracy* and *comprehension*): no outliers were found (see Appendix E, Figure E2). Two outliers were found for *alcohol*; neither of the outliers identified were due to recording or data entry errors, they were representative of the population sampled. At the same time, however, they were not representative of the levels of alcohol exposure the sample as a whole were exposed to, and so had the potential to bias subsequent statistical models. In order to control for these outliers the scores were changed to the value equivalent to two standard deviations of the mean (see Appendix E, Figure E3; Field, 2005). Even after the change these two outliers remained as such and were expected to influence the regression model, therefore generalisations made about the results found were done so with caution. No outliers were found for *IQ* (see Appendix E, Figure E4). Descriptive statistics for the PhAB performance measures, NARA age equivalent scores, *alcohol* and *IQ*, across the entire sample, can be seen in Table 7. The multiple regression analyses for the PhAB performance measures will be discussed first; the multiple regression analyses for the NARA reading age equivalent scores will be discussed after that.

Table 7. Descriptive statistics for the PhAB performance measures, NARA age equivalent scores, *alcohol*, and *IQ*

Variable	Minimum	Maximum	Mean	*SD*
PhAB subtest				
Phonological awareness	4	20	13.57	4.39
Phonological production speed	59	165	93.24	26.02
Phonological fluency	2	14	8.67	2.83
Non-phonological fluency	9	26	16.50	4.20
NARA				
Rate	6.00	10.08	7.32	1.33
Accuracy	6.01	12.06	9.01	2.03
Comprehension	6.03	11.06	8.45	1.46
Alcohol[a]	0.00	6.47	1.51	1.79
IQ[b]	40	88	67.15	11.90

Note. PhAB = Phonological Assessment Battery.
[a]Alcohol expressed as AA/day;
[b]IQ expressed as an estimate of IQ.

Determining the relationship between alcohol and the PhAB performance measures

The aims of these analyses were to determine a) if there was a relationship between the children's performances on the PhAB measures and *alcohol* and b) how another predictor variable, *IQ*, might have influenced this relationship. In other words, if a significant relationship is found between the *PhAB* performance measures and *alcohol* it is necessary to determine whether this relationship exists after the contribution of *IQ* has been accounted for.

Tests of normality. Kolmogorov-Smirnov tests were carried out on the PhAB performance measure data, as well as on the *alcohol* and *IQ* measure data, to determine the normality of those distributions. The distributions of data for PhAB phonological awareness, phonological fluency, and non-phonological fluency, as well as that for *IQ*, were normal, $D(42) = 0.10$, $D(42) = 0.11$, $D(42) = 0.10$, $D(42) = 0.13$, respectively; $p > .05$ in all cases. The distribution for PhAB phonological production speed and alcohol were significantly non-normal, however, $D(42) = 0.15$ and $D(42) = 0.24$; $p < .05$ in both cases. As a result the parametric Pearson's correlation coefficient (r) was used for the next step in the analysis of the three PhAB performance measures and *IQ*, while the non-parametric Spearman's correlation coefficient (rho) was used for analysis of *alcohol*.

Correlation matrix. Following Field (2005), the correlation matrix shown in Appendix F, Table F1 was designed to show whether a) significant or possible trend correlations existed between *alcohol* and the PhAB performance measures, b) significant or possible trend correlations existed between *IQ* and the PhAB performance measures, and c) multicollinearity ($R > .80$) existed between alcohol and *IQ*. As the table shows, the only statistically significant relationships were between (1) *alcohol* and PhAB phonological production speed, and (2) *IQ* and PhAB phonological production speed and phonological fluency. This provides evidence to suggest that level of prenatal alcohol exposure only has an effect on phonological production speed abilities. *IQ* was also found to be related to this measure and as a result a multiple regression analysis will be conducted to determine the nature of these two predictors in predicting the outcome variable. No multicollinearity existed between *alcohol* and *IQ*, thus allowing for them to be entered into the PhAB phonological production speed multiple regression analysis. Multiple regression analyses will not be conducted for the PhAB phonological awareness, phonological fluency or non-phonological fluency performance measures as no significant relationships were found between these outcome variables and level of prenatal alcohol exposure.

Multiple regression analysis: PhAB phonological production speed. *Alcohol* and *IQ* were entered into the multiple regression analysis simultaneously. Table 8 shows that the participants' PhAB phonological production speed performance measures were not significantly predicted by *alcohol* or *IQ*, but that represented possible trend relationships. Together, these two predictor variables accounted for approximately 19% of the variance in PhAB phonological production speed performance measures, $F(2,41) = 4.43$, $p < .01$ (see Table 9).

With regard to the assumptions underlying regression analyses, all were met except for the normality of the standardized residuals distribution, $D(42) = 0.17$, $p < .05$. The four cases influencing the model are the two alcohol outliers (cases 1 and 15) and the two phonological production speed outlier (cases 28 and 37); their diagnostics can be seen in Appendix G, Figure G1. These influences on the model were expected and as a result, generalisations made from this model of this sample to the population are done with caution despite information in Table 9 suggesting that the cross-validity of this model is acceptable (the current model would account for approximately 5% less variance if the data were obtained from the population rather than the sample).The current multiple regression yields a post-hoc

statistical power of approximately .80 when a medium effect size (.25) is used alongside an alpha level of .05, two predictors, and the current sample size of 42 (G-power program; Faul, Erdfelder, Lang, & Buchner, 2007).

With regard to regression model diagnostics, residual statistic analyses revealed one standardised residual with an absolute value above 3; this finding is not within the acceptable range for a population of this size, which suggests that the model is a poor representation of the actual data (Field, 2005). Three leverage values were greater than three times the average leverage value; two leverage values represent the outliers within the *alcohol* data and one represents the outlier in the PhAB phonological production performance measures (see Appendix G, Table G1). The influence of these values on the regression model has already been explained.

Table 8. Multiple regression model results: PhAB phonological production speed

	B	*SE B*	*B*	*p*
Model 1				
Constant	85.57	5.01		
Alcohol (oz/day)	5.08	2.16	.35	.023*
Model 2				
Constant	124.52	22.95		
Alcohol (oz/day)	4.28	2.15	.29	.054^
IQ	-0.56	0.32	-.26	.090^

Note. Data based on 42 participants.

R^2 = .12 for Step 1; ΔR^2 = .19 for Step 2.

^$p < .10$.

Table 9. Model summaries and ANOVA results: PhAB phonological production speed

		Change Statistics			ANOVA	
Model	Adjusted R^2	ΔR^2	ΔF	Δp	*F*	*p*
1	.10	.12	5.55	.023*	5.55	.023*
2	.14	.06	3.02	.090^	4.43	.019*

^$p < .10$, *$p < .05$.

Determining the relationship between alcohol and the NARA reading age equivalent scores
The aims of these analyses were to determine a) if there is a relationship between the children's NARA reading age equivalent scores and *alcohol*, and b) how *IQ* and performance on three subtests of the PhAB (*phonological awareness*, *phonological production speed* and *phonological fluency*) might have influenced this relationship. In other words, if a significant relationship exists between NARA performance and *alcohol* it is necessary to determine whether this relationship will continue to exist after the contributions of *IQ* and phonological abilities have been controlled for.

Tests of normality. To determine the normality of their distributions, separate Kolmogorov-Smirnov tests were carried out on the data for three NARA outcome measures. The distributions of the data for NARA *rate*, *accuracy*, and *comprehension* were all statistically significantly non-normal, $D(42) = 0.22$, $D(42) = 0.16$, and $D(42) = 0.15$, respectively ($p < .05$ in each case). Consequently, the non-parametric Spearman's correlation coefficient (rho) was used in the next step of the analysis of the three NARA age equivalent scores.

Correlation matrix. Again following Field (2005), the correlation matrix shown in shown in Appendix F, Table F2 was designed to show whether a) significant or possible trend correlations existed between alcohol and the NARA age equivalent scores, b) significant or possible trend correlations existed between *IQ* and the NAR age equivalent scores, and c) multicollinearity ($R > .80$) existed between *alcohol* and *IQ*. As the table shows, *alcohol* was statistically significantly related to the NARA rate age equivalent scores, and the relationship between *alcohol* and the NARA accuracy and comprehension age equivalent scores approached statistical significances. This provides evidence to suggest that level of prenatal alcohol exposure has an effect on reading rate abilities only, with possible trend relationships existing between level of prenatal alcohol exposure and reading accuracy and comprehension abilities only. *IQ* and the three PhAB phonological performance measures were significantly correlated with all three NARA age equivalent scores and as a result multiple regression analyses will be conducted to determine the nature of these predictors (i.e., *alcohol*, *IQ*, and the PhAB performance measures) in predicting all three NARA age equivalent scores. No multicollinearity existed between *alcohol*, *IQ* and the PhAB performance measures, thus allowing for them to be entered into the NARA rate, accuracy and comprehension multiple regression analyses.

Multiple regression analysis: NARA rate. *Alcohol*, *IQ* and the three PhAB phonological performance measures were entered into the multiple regression analysis simultaneously. Table 10 shows that the children's NARA rate age equivalent scores were significantly predicted by PhAB phonological awareness measures and that *alcohol* and the PhAB phonological fluency measures relationships approached statistical significance. Together, all of the predictor variables entered into the regression analysis accounted for approximately 62% of the variance for NARA rate age equivalent scores, $F(5,41) = 11.99$, $p = .000001$ (see Table 11).

With regard to the assumptions underlying regression analyses, all were met except for that of heteroscedasticity (see Appendix H, Figure H1). As a result of this assumption being violated the current model must be generalised cautiously despite information in Table 11 suggesting that the cross-validity of this model is acceptable (this model would account for approximately 6% less variance if the data were obtained from the population rather than the current sample). The current multiple regression yields a post-hoc statistical power of approximately .63 when a medium effect size (.25) is used alongside an alpha level of .05, five predictors, and the current sample size of 42 (G-power program; Faul et al., 2007). With regard to regression model diagnostics, two covariance ratios lay outside the acceptable calculated covariance ratio boundaries; one (case 15) represents an outlier in the *alcohol* data and one (case 27) represents an outlier in the PhAB phonological production speed performance measure. Cook's distance for these two cases is well below zero, indicating that there is probably little cause for concern (Field, 2005; see Appendix G, Table G2).

Table 10. Multiple Regression Model Results: NARA rate

	B	*SE B*	*β*	*p*
Model 1				
Constant	7.71	0.26		
Alcohol (oz/day)	-0.26	0.11	-.36	.021*
Model 2				
Constant	5.64	1.28		
Alcohol (oz/day)	-0.15	0.08	-.20	.078^
IQ	-0.00	0.01	-.02	.858
Phonological awareness	0.26	0.06	.84	.0004***
Phonological production speed	-0.00	0.01	-.07	.643
Phonological fluency	-0.13	0.07	-.27	.067^

Note. Data based on 42 participants.

R^2 = .12 for Step 1; ΔR^2 = .62 for Step 2

^p < .10, *p < .05, ***p < .001.

Table 11. Model Summaries and ANOVA Results: NARA rate

		Change Statistics			ANOVA	
Model	Adjusted R^2	ΔR^2	ΔF	Δp	F	p
1	.10	.13	5.76	.021*	5.76	.021*
2	.57	.50	11.97	.000003*****	11.99	.000001******

*p < .05, *****p < .00001, ******p < .000001.

Multiple regression analysis: NARA accuracy. *Alcohol*, *IQ* and the PhAB phonological performance measures were entered into the multiple regression analysis simultaneously. Table12 shows that the children's NARA accuracy age equivalent scores were significantly predicted by PhAB phonological awareness only. Together, all the predictor variables entered into the regression analysis accounted for approximately 65% of the variance for NARA accuracy age equivalent scores, $F(5,41) = 13.23$, $p = .0000002$ (see Table 13).

With regard to the assumptions underlying regression analyses, all were met except for that of heteroscedasticity (see Appendix H; Figure H2). As a result of this assumption being violated the current model must be generalised cautiously despite information in Table 13

suggesting that the cross-validity of this model is acceptable (the current model would account for approximately 5% less variance if the data were obtained from the population rather than the sample). The current multiple regression yields a post-hoc statistical power of approximately .63 when a medium effect size (.25), using an alpha level of .05, five predictors, and the current sample size of 42 (G-power program; Faul, et al., 2007).

With regard to regression model diagnostics, four covariance ratios lay outside the acceptable calculated covariance ratio boundaries; two (cases 1 and 15) represent outliers in the *alcohol* data, one (case 37) represents an outlier in the PhAB phonological production speed performance measure and one (case 27) does not represent an outlier in any of the data. Cook's distance for these four cases is well below zero, indicating that there is probably little cause for concern (Field, 2005; see Appendix G, Table G3).

Table 12. Multiple Regression Model Results: NARA accuracy

	B	*SE B*	*B*	*P*
Model 1				
Constant	9.42	0.37		
Alcohol (oz/day)	-0.25	0.13	-.29	.063^
Model 2				
Constant	4.65	1.91		
Alcohol (oz/day)	-0.01	0.09	-.12	.290
IQ	0.02	0.02	.12	.339
Phonological awareness	0.35	0.09	.75	.0005***
Phonological production speed	-0.01	0.01	-.08	.615
Phonological fluency	-0.13	0.10	-.18	.209

Note. Data based on 42 participants.

$R^2 = .10$ for Step 1; $\Delta R^2 = .65$ for Step 2.

^$p < .10$, ***$p < .001$.

Table 13. Model Summaries and ANOVA Results: NARA accuracy

		Change Statistics			ANOVA	
Model	Adjusted R^2	ΔR^2	ΔF	Δp	F	P
1	.07	.10	4.18	.048*	4.18	.048*
2	.60	.55	14.13	.000001*****	13.23	.0000002*****

*$p < .05$, *****$p < .000001$.

Multiple regression analysis: NARA comprehension. *Alcohol*, *IQ* and the PhAB phonological performance measures were entered into the multiple regression analysis simultaneously. Table 14 shows that the children's NARA comprehension age equivalent scores were significantly predicted by PhAB phonological awareness and that IQ represented a possible trend relationship. Together, all the predictor variables entered into the regression analysis accounted for approximately 66% of the variance for NARA comprehension age equivalent scores, $F(5,41) = 13.99$, $p = .0000001$ (see Table 15).

With regards to the assumptions underlying regression analysis, all were met except for that of heteroscedasticity (see Appendix H, Figure H3). As a result of this assumption being violated the current model must be generalised cautiously despite information in the Table 15 suggesting that the cross-validity of this model is acceptable (the current model would account for approximately 5% less variance if the data were obtained from the population rather than the current sample). The current multiple regression yields a post-hoc statistical power of approximately .63 when a medium effect size (.25), using an alpha level of .05, five predictors, and the current sample size of 42 (G-power program; Faul et al., 2007).

With regard to regression model diagnostics, five covariance ratios lay outside the acceptable calculated covariance ratio boundaries; one (cases 1) represents an outlier in the *alcohol* data, two (case 28 and 37) represent outliers in the PhAB phonological production speed performance measure and two (cases 27 and 33) does not represent an outlier in any of the data. Cook's distance for these four cases is well below zero, indicating that there is probably little cause for concern (Field, 2005; see Appendix G, Table G4).

Table 14. Multiple Regression Model Results: NARA comprehension

	B	*SE B*	*B*	*p*
Model 1				
Constant	8.82	0.28		
Alcohol (oz/day)	-0.23	0.11	-.33	.035*
Model 2				
Constant	4.98	1.34		
Alcohol (oz/day)	-0.08	0.08	-.12	.278
IQ	0.03	0.02	.24	.057^
Phonological awareness	0.19	0.07	.56	.006**
Phonological production speed	-0.01	0.01	-.13	.381
Phonological fluency	-0.04	0.07	-.07	.609

Note. Data based on 42 participants.

R^2 = .11 for Step 1; ΔR^2 = .66 for Step 2

^p < .10, *p < .05, **p < .01.

Table 15. Model Summaries and ANOVA Results: NARA comprehension

		Change Statistics			ANOVA	
Model	Adjusted R^2	ΔR^2	ΔF	Δp	*F*	*p*
1	.08	.11	4.75	.035*	4.75	.035*
2	.61	.55	14.68	.0000003*****	13.99	.0000001******

*p < .05, *****p < .000001, ******p < .0000001.

DISCUSSION

The specific objectives of the current study were to explore the phonological abilities and prevalence of developmental reading skill deficits in school-aged children (Grades 3-7) who were exposed to alcohol prenatally. An adapted and translated Afrikaans version of the Phonological Assessment Battery (PhAB; Frederickson et al., 1997) produced three composite performance measures (*phonological awareness*, *phonological production speed*, and *phonological fluency*) that were used to assess phonological skills, as well as a composite measure of *non-phonological fluency*. An adapted and translated Afrikaans version of the Neale Analysis of Reading Abilities (NARA; Bower & Hartman, 2006) produced three reading age equivalent scores (*rate*, *accuracy* and *comprehension*) that were used to assess developmental reading skills. Depending on the nature of the analysis, variability in prenatal exposure to alcohol was expressed as either a dichotomy (exposed versus non-exposed; two-group analysis), a categorical variable based on dysmorphological diagnosis (FAS/pFAS, OHE, or Control; three-group analysis), or as a continuous variable (AA/day across the pregnancy; regression-based analysis).

With regard to the first of the PhAB-based composite measures, *phonological awareness*, the findings in the current research did not confirm the *a priori* hypothesis that there would be statistically significant between-group differences in both the two- or three-group analyses. Similarly, the current study's findings did not confirm the *a priori* hypothesis that a linear relationship would exist between the level of prenatal alcohol exposure and phonological awareness abilities: Correlation matrices performed for the purpose of the multiple regression analysis did not show a significant relationship between level of prenatal alcohol exposure (AA/day) and PhAB phonological awareness performance.

These data are inconsistent with the findings of Adnams et al. (2007), who reported statistically significant performance differences between children with FASD and control children on measures of phonological awareness. The discrepancy between their finding and the finding in the current study is not due to different attributes of the two samples: the participants in both studies were from similar socio-economically disadvantaged communities in the Western Cape, and were similar in age and developmental range.

Another possibility to consider is that the current study's relatively small sample size (N = 46, compared to Adnams et al.'s (2007) sample size of N = 105) did not generate enough analytic power to detect an effect that is definitely present in the population. However, considering the average effect size in the Adnams et al. (2007) report and given the current study's sample size, the power of the current two- and three-group comparisons is .93. There was therefore enough power in the current research to detect an effect if one was indeed present.

A more likely reason for the observed discrepancy is that these two studies assessed two different things. In research focused on phonological awareness, several different tasks are used to assess, and subsequently characterize, the phonological awareness construct. These tasks vary in their linguistic complexity demands (Stahl & Murray, 1994). Adams (1990) describes a hierarchy of tasks assessing phonological awareness skills according to lower- and higher-order demands on linguistic complexity. First-level tests assess one's ability to identify the sounds of words (for example, familiar beginning and end sounds in words). Second-level tests demand more focused attention than first-level tests because they include identifying and sorting patterns of rhyme and alliteration in words. Third-level tests assess one's knowledge of individual phonemes and their associated sounds within words. Tests requiring one to identify the initial phonemes of words or to blend separate phonemes into words would fall into this level. Fourth-level tests require the full segmentation of component phonemes and the fifth level, containing the most difficult tests, requires one to add, delete or move individual phonemes from given words and to thus create new words or pseudo-words.

If the phonological awareness tests used in the current study (i.e., those from the PhAB) and those used in the Adnams et al. (2007) study (i.e., those from the PAELT) are categorised according to Adams' (1990) hierarchy, it is clear that they are assessing levels of phonological awareness that are of different difficulty. For instance, the PAELT letter sounds test would fall into the first level category. The PhAB alliteration and rhyme tests would fall into the second category level. The PAELT blending syllables and phonemes tests would fall into the third level category. The PAELT first, last and all sounds segmentation tests would fall into the fourth level category. The PhAB spoonerisms test and the PAELT manipulating syllables and phonemes tests would fall into the fifth level category. The PhAB non-word reading test does not fall into this classification system. It is evident from this categorisation that the phonological awareness abilities assessed by the PhAB include only two levels of

linguistic complexity; in contrast, the PAELT assesses at four out of the five levels. With regard to the PhAB, two out of the four tests in the composite phonological awareness measure are classified as level two tests. They carry more weight in the PhAB composite measure compared to the level one test in the PAELT composite measure and as such have more influence in affecting the composite measure. It is therefore possible, given the patterns of data across the two studies, that children prenatally exposed to alcohol perform similarly to non-exposed children at the easier levels, but struggle more at the difficult levels; thus, the current study detected no between-group differences while Adnams et al. (2007) detected statistically significant between-group differences.

To resolve this discrepancy, future researchers may want to explore a broader range of phonological awareness skills than the range assessed individually by the two previous studies. One possibility is to administer the PAELT in conjunction with Bradley and Bryant's (1983) sound categorisation test, which assesses skills representative of Adams' (1990) second level of difficulty (a level not covered by the PAELT). An adapted and translated Afrikaans version of Bradley and Bryant's (1983) test, which has been found to detect phonological awareness differences in an Afrikaans-speaking sample of children in South Africa, can be found in Cockcroft, Broom, Greenop, and Fridjohn (2001). This type of exploration, using an extensive test battery, may shed more conclusive light on phonological awareness skills in children with FASD.

With regard to the second of the PhAB-based composite measures, *phonological production speed* (based on performance on picture- and digit-naming tasks), findings in the current research did not confirm the *a priori* hypothesis that there would be statistically significant between-group differences in the two- and three-group analyses. Similarly, the current data did not confirm the *a priori* hypothesis that a linear relationship would exist between level of prenatal alcohol exposure and phonological production speed abilities. Although correlation matrices performed for the purpose of the multiple regression analysis showed a significant relationship between level of prenatal alcohol exposure (AA/day) and phonological production speed, multiple regression results showed only a possible trend relationship between those two variables after controlling for the effect of IQ. This finding may be due to the way in which the level of prenatal alcohol exposure was measured; as an average level of absolute alcohol across the entire pregnancy. If level of prenatal alcohol exposure was

measured in a different way, an effect of exposure on phonological production speeds may have been found.

Goldschmidt et al. (1996) found a dose-response relationship specific to the second trimester of pregnancy: In their study, any prenatal exposure above the threshold of one drink per day had a significant effect on letter-naming abilities in FASD children. By way of contrast, the current findings are based on an estimated average of alcohol consumption per day across the entire pregnancy, and the production speed outcome variable is based on picture- and digit-naming abilities. A possible question of interest for future researchers would therefore be whether a dose-response relationship, similar the one described by Goldschmidt et al. (1996), could be replicated using these two subtests of the PhAB.

The PhAB picture- and digit-naming subtests assess children's retrieval of phonological coding at the whole word level and are representative of processing speed ability (Frederickson et al., 1997; Pogorzelski & Wheldall, 2002). Some researchers in the field of developmental reading difficulties and dyslexia have found that children struggling to read can perform poorly on (a) phoneme awareness tasks, (b) processing speed tasks or (c) both of these tasks (i.e., evince a double deficit). These researchers thus identify a processing speed deficit as being a distinct underlying problem, separate from a phonological awareness deficit (Wolf & Bowers, 1999). Findings from the current study suggest that children most severely affected by the teratogenic effects of prenatal alcohol exposure may suffer from reading disabilities because of an underlying processing speed deficit rather than because of a phonological awareness deficit or a double deficit.

Wolf (2000) suggests that a processing speed deficit seen in reading disabilities may generalise to other domains of cognitive processing speed (e.g., visual, auditory, or motor). Previous studies on infants and children with prenatal exposure to alcohol have reported the presence of cognitive processing speed deficits (Jacobson, Jacobson, Sokol, Martier, & Ager, 1993; Streissguth, Barr, & Sampson, 1990). These findings, in conjunction with the current study's finding of a possible trend relationship between level of prenatal alcohol exposure and phonological processing speed abilities, highlight the need for further exploration of these abilities in the FASD population in order to determine whether one might justifiably include a phonological processing speed deficit in the typical cognitive profile of children with FASD.

With regard to the third and fourth of the PhAB-based composite measures, *phonological fluency* and *non-phonological fluency*, the skills assessed are verbal fluency abilities. Verbal fluency tasks assess an individual's cognitive flexibility and strategic thinking (skills of executive functioning) and are performed under certain time constraints (Malloy & Richardson, 1994). Tasks of letter fluency (rapid production of words starting with a certain letter) and category fluency (rapid production of words describing items belonging to a certain category) are commonly used to assess verbal fluency. Previous research conducted in the United States and South Africa has suggested that children with FASD experience verbal fluency deficits. More specifically, children with FAS/FAE tend to (a) perform more poorly on tests of letter fluency than on tests of categorical fluency, and (b) perform more poorly on both measures in comparison to non-exposed control children (Kodituwakku et al., 1995, 2006; Mattson & Riley, 1999; Schonfeld, Mattson, Lang, Delis, & Riley, 2001).

The PhAB phonological fluency measure is a combined score of the participants' alliteration (letter) fluency and rhyme fluency abilities. This measure is concerned with the participants' ability to easily and fluidly produce words that are phonologically associated with each other. The current data suggested no significant between-group differences (in either the two- or three-group analyses) on this measure: Correlation matrices performed for the purpose of the multiple regression analysis also did not show a statistically significant relationship between level of prenatal alcohol exposure (AA/day) and phonological fluency.

This finding is not congruent with those from previous studies assessing verbal fluency in children with FASD (e.g., Mattson & Riley, 1999; Kodituwakku, et al., 1995, 2006; Schonfeld et al., 2001), where letter fluency in alcohol-exposed participants has been found to be significantly worse than that in non-exposed participants. The reason for this discrepancy may be due to differences in the way in which the tests were administered. In the current study, the verbal fluency subtests each allowed a time limit of only 30 seconds, whereas in all of the previous studies the time limit was 60 seconds. The participants' performances were not tracked within the 30 and 60 second time-limits, and as such participants' performance levels within the first 30 seconds across studies could not be assessed. Assessing the number of words generated in 15-second intervals is recommended as it allows for a more in-depth analysis of performance (Miller, 2007). For instance, three participants may achieve the same total number of words (for example, 14); one participant may generate these 14 words within the first two 15-second intervals, another participant may

generate the 14 words over all four 15-second intervals, and the third may fail to generate any words in the first 15 seconds but may generate the 14 words in the last three 15-second intervals. These three performances are qualitatively different, and may reflect different underlying cognitive styles or impairments that are not captured by the typical total-score analysis.

This 15-second interval style of data collection is thus important (a) for qualitative interpretation of the results as it allows the researcher to identify participants who may have processing speed or initiation deficits (Miller, 2007), and (b) because it allows for comparisons between participants' performances across different studies. Given that the previous studies do not explore the number of words generated within the first two 15-second intervals and the current research only shows a number representative of the full 30-second time limit, true comparisons between the results of those studies and the results from this study cannot be made. This issue could be explored in future FASD research to discern whether there is a pattern of word-generation disabilities specifically associated with prenatal alcohol exposure.

The PhAB non-phonological fluency measure is based on performance on a category fluency task. This measure is concerned with the participants' ability to easily and fluidly produce words that are semantically associated with each other. There were no statistically significant between-group differences in the two-group analysis, but there were such differences in the three-group analysis. Specifically, participants in the FAS/pFAS group performed more poorly than those in the OHE group, with the performance of participants in the Control group falling between the two. This finding is inconsistent with previous research which, using a similar task, found statistically significant performance differences between heavily exposed children and normal controls (Mattson & Riley, 1999) and similar performances in FAS and OHE participants (Schonfeld et al., 2001). Correlation matrices performed for the purpose of the multiple regression analysis of the PhAB non-phonological fluency measure did not show a relationship between level of prenatal alcohol exposure (AA/day) and the outcome variable, however.

There is no obvious or theoretically plausible explanation for the sole between-group difference found in the current research; it does not seem to represent an alcohol effect, as no statistically significant difference was found between exposed children and the non-exposed

controls, and the correlation matrices showed no statistically significant associations. Similarly to the issue stated in the discussion above, there was no tracking of words generated in the 30- and 60 second time-limits for the current and previous research, and as such the current results in the current research cannot be compared to those reported in previous studies.

On average, all participants in this study produced double the amount of words for non-phonological fluency (category fluency) than for phonological fluency (letter fluency, rhyme fluency). This finding is consistent with previous research which has found all participants' performances on category fluency to be significantly better than performances on letter fluency (Kodituwakku et al., 2006; Mattson & Riley, 1999). Evidence from research conducted by Ho et al. (2002) suggests that letter fluency predominantly relies on phoneme-switching abilities, whereas category fluency predominantly relies on semantic grouping abilities. The latter is generally considered to be a more difficult ability to master than the former, thus explaining the consistently discrepant performance across tasks.

With regard to the second set of outcome measures, the hypothesis that non-exposed participants would have reading levels below those of their chronological age was confirmed. This result supports findings by Adnams et al. (2007) that even non-exposed South African children perform below the chronological age norms established by tests developed in Western countries. A national summary report assessing the reading achievements of South African Grade 4 and Grade 5 learners in comparison to the achievements of learners within the educations systems of 44 other countries found that South African learners scored the lowest on measures of reading achievement. That report indicates that, within the South African sample, more than half the English and Afrikaans learners and more than 80% of the African-language speakers assessed did not reach the lowest international benchmark for reading abilities, rendering these children without basic reading skills or strategies to enable them to cope with academic tasks (Venter et al., 2007).

The hypothesis that participants in the FAS/pFAS group would perform significantly more poorly than participants in the OHE and Control groups on measures of reading ability (NARA *rate*, *accuracy*, and *comprehension*) was not confirmed. This piece of data suggests, then, that alcohol may not have an effect on reading abilities. Multiple regression-based analyses confirmed the above pattern of data by showing that level of alcohol exposure

(AA/day) was not significantly related to reading abilities once other predictor variables had been entered into the analysis. Additionally, these multiple regression analyses showed that phonological awareness was significantly related to reading abilities. This is consistent with the developmental reading disability literature which reports on a strong relationship between phonological awareness abilities and reading achievement (Stahl & Murray, 1994).

No other research has assessed the reading rate or reading accuracy abilities of children with FASD using a paragraph reading paradigm. Therefore, the current findings are unique and require replication in larger samples.

The finding reported above for reading comprehension abilities is inconsistent with that reported by Sampson et al. (1997), who found that prenatal alcohol exposure was highly significantly associated with performance on a reading comprehension task. Sampson and colleagues specifically found that FASD adolescents, who were exposed to higher levels of prenatal alcohol, performed more poorly than adolescents exposed to lower levels of prenatal alcohol, on anaphoric comprehension questions, but on not memory or inference questions. The measure of comprehension used in the current study did not distinguish between different types of comprehension questions, and so one cannot engage in an in-depth analysis of which types of questions the current participants may have struggled with. Further research would benefit from having a more in-depth measure of reading comprehension measure which would allow for the exploration of this type.

Overall, then, results from the current study do not support the inclusion of deficits in phonological abilities or deficits in reading skills as part of the cognitive profile for children with FASD. Furthermore, the current study highlights the need for improved literacy programmes and instruction within the South African schooling systems as well as the need for phonological and literacy intervention programmes for children already within this system.

Limitations and Consequent Directions for Future Research

There were a number of limitations within the current study. Threats to internal and external validity with regard to outliers, influential cases and distribution non-normalities influenced the extent to which one could infer causal relationships and the directions of these relationships between groups or cases. Threats to construct validity, such as the

measurements of phonological awareness, phonological fluency and non-phonological fluency, were discussed previously and cause room for concern when discussing and comparing the current findings to those of previous research. Each of these limitations will be discussed in turn below.

A major limitation of the current research relates to the tests used to assess the abilities of interest. There are no published or normed Afrikaans tests of phonological awareness. As a result the phonological abilities of the children in the current study were assessed utilising an adapted and translated version of the Phonological Assessment Battery, an English test normed on a European population. Despite efforts from our research group to develop items of similar phonological and conceptual demands to the original English version of the PhAB, the reliability and validity of the Afrikaans test items are currently unknown. With regard to the NARA, the situation is a little better: South African Afrikaans norms are available, although no psychometric information is available for the Afrikaans version of the test.

The second major limitation of the current study was that it featured a relatively small sample ($N = 46$). Although this small sample size can be attributed to the fact that the study was exploratory in nature (its overall objective was to determine whether the investigations of phonological and reading abilities within the larger study would prove fruitful), the fact that it was so small influenced the power the statistical analyses had to detect effects present in the population. Additionally, the small *N* may have contributed to the fact that the data distributions for many of the PhAB subtest scores and NARA outcome variables were non-normal. Future research based on a larger sample size might thus produce data with more normal distributions that will either (a) replicate the findings of the current research, or (b) detect alcohol effects not found here due to a lack of power.

The third major limitation of the current study was related to test administration. More specifically, the phonological awareness and phonological fluency subtests of the PhAB seemed to be testing different types of performances than the previous research done in both of these areas. In order to ascertain whether the appropriate skills are being assessed and to assist in between-research comparisons future studies should try to provide as in-depth an analysis of performance as possible.

The fourth major limitation was the lack of generalisability of the multiple regression models for the NARA scores as a result of the assumption of homoscedascity not being met. The two most influential cases in these analyses were participants who had been exposed to significantly larger amounts of alcohol prenatally than the other exposed children. Future research should focus on including more participants with higher levels of prenatal alcohol exposure in order to determine what effects large amounts of alcohol have on phonological abilities and reading skills.

A final limitation of the current study is that cognitive-affective factors such as the participant's working memory, motivation, alertness, concentration or anxiety were not measured as part of the data collection; similarly, possible experimenter effects on participant performance were not closely monitored. Although every effort was made to ensure the participants were comfortable and had a break between test administrations, some of the factors listed above may still have impacted upon participants' performances. To address this limitation, future researchers should consider administering a comprehensive battery of neuropsychological and affective tests to participants in order to enable analytic control of cognitive-affective states. Similarly, future researchers should consider filming the testing sessions for post-administration analyses so as to control for possible experimenter biases.

Conclusion

The cognitive phenotype of children with FASD is largely unexplored. Published research concerning the teratogenic effects of alcohol on reading skills and phonological awareness abilities in children with FASD is limited. These skills are essential for successful school achievement and therefore knowledge of deficits in these areas specific to FASD is essential; such knowledge can help inform diagnostic and intervention programmes that may limit the effects such deficits can have on school success. The current research did not find any specific deficits in phonological awareness abilities or reading skills in the alcohol-exposed sample, suggesting that deficits in these areas of cognition should not be included in the FASD cognitive phenotype. This finding is not conclusive, however, and further exploration of these abilities with a larger group of FASD children and with more defined measures of phonological awareness abilities and reading skills should prove fruitful.

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APPENDIX A

Test Items from the Original PhAB Battery and the Translated and Adapted Afrikaans Test Items

Table A1. Words used within the PhAB phonological awareness alliteration subtests

English words				Afrikaans words			
shop	mat	shell	(sh)	son	mat	seun	(s)
lot	less	mud	(l)	les	mes	man	(m)
pick	pat	run	(p)	pak	pot	red	(p)
ship	fat	fox	(f)	net	nie	sak	(n)
mug	zip	men	(m)	dag	pot	duif	(d)
bike	name	nose	(n)	hok	tak	tyd	(t)
dig	dot	pen	(d)	kop	kam	bul	(k)
tin	sack	top	(t)	bed	man	mat	(m)
snake	clap	crawl	(c)	skoen	brood	brand	(b)
plate	pram	draw	(p)	skip	plaas	staan	(s)
sleep	clown	snail	(s)	trap	koud	troon	(t)
cross	twig	truck	(t)	plaat	pret	staan	(p)
drip	skirt	dwarf	(d)	skool	klomp	kraan	(k)

Table A2. Words used within the PhAB phonological awareness rhyme subtests

English words			Afrikaans words		
made	hide	fade	pot	straf	laf
wig	fig	pin	eet	sak	meet
bus	harm	farm	sit	net	wit
pack	lack	sag	dag	lag	dit
sap	hop	top	tas	ken	pen
nut	cut	pet	rek	byt	bek
sand	hand	cup	min	sin	tol
cat	fan	mat	bad	kos	los
dot	mop	top	het	vat	met
tub	mud	cub	pop	sop	byl
dog	man	fog	af	bul	laf
sip	win	bin	om	by	sy

Table A3. Words used within the PhAB phonological awareness spoonerisms subtests

English words				Afrikaans words			
Subtest 1				Subtest 1			
cot	with a /g/	gives	(got)	sak	met n /t/	gee	(tak)
fun	with a /b/	gives	(bun)	sit	met n/d/	gee	(dit)
red	with a /b/	gives	(bed)	rol	met n/k/	gee	(kol)
go	with a /s/	gives	(so)	man	met n/k/	gee	(kan)
might	with a /f/	gives	(fight)	pen	met n/w/	gee	(wen)
make	with a /t/	gives	(take)	pak	met n/s/	gee	(sak)
need	with a /st/	gives	(steed)	lag	met n/s/	gee	(sag)
gaze	with a /cr/	gives	(craze)	pad	met n/b/	gee	(bad)
stoke	with a /br/	gives	(broke)	sug	met n/l/	gee	(lug)
crime	with a /ch/	gives	(chime)	sin	met n/m/	gee	(min)
Subtest 2				Subtest 2			
sad cat		gives	(cad sat)	veel meer		gee	(meel veer)
big pip		gives	(pig bip)	donker		gee	(konker
fed man		gives	(med fan)	meer kos		gee	(keer mos)
boast core		gives	(coast bore)	gaan loop		gee	(laan goop)
riding boot		gives	(biding root)	sonder		gee	(honder
float down		gives	(dote floun)	my kat		gee	(ky mat)
prickley man		gives	(mickly pran)	goed koop		gee	(koed goop)
which brute		gives	(britch woot)	koue		gee	(doue
crowded		gives	(shoudedcrip)	bitter		gee	(kitter
plane crash		gives	(crane plash)	dom seun		gee	(som deun)

Table A4. Words used within the PhAB phonological awareness non-word reading subtests

English non-words	Afrikaans non-words
List 1	List 1
pim	tov
gat	sen
fot	bot
lub	gaam
hin	gens
chog	glaar
trum	duis
pran	wer
nabe	sil
leaze	laak
List 2	List 2
haplut	resig
yutmip	sele
musnate	meker
pootfeg	mogter
shendom	bierso
ligtade	sigter
cromgat	sinter
ropsatch	tomer
rissbick	kater
plutskirl	loomte

Table A5. Words used within the PhAB phonological fluency alliteration and rhyme subtests and the PhAB non-phonological fluency semantic subtests

English words	Afrik
Semantic	Semantic
things to eat	dinge om te eet
animals	diere
Alliteration	Alliteration
/m/	/m/
/b/	/b/
Rhyme	Rhyme
more	meer
whip	skip

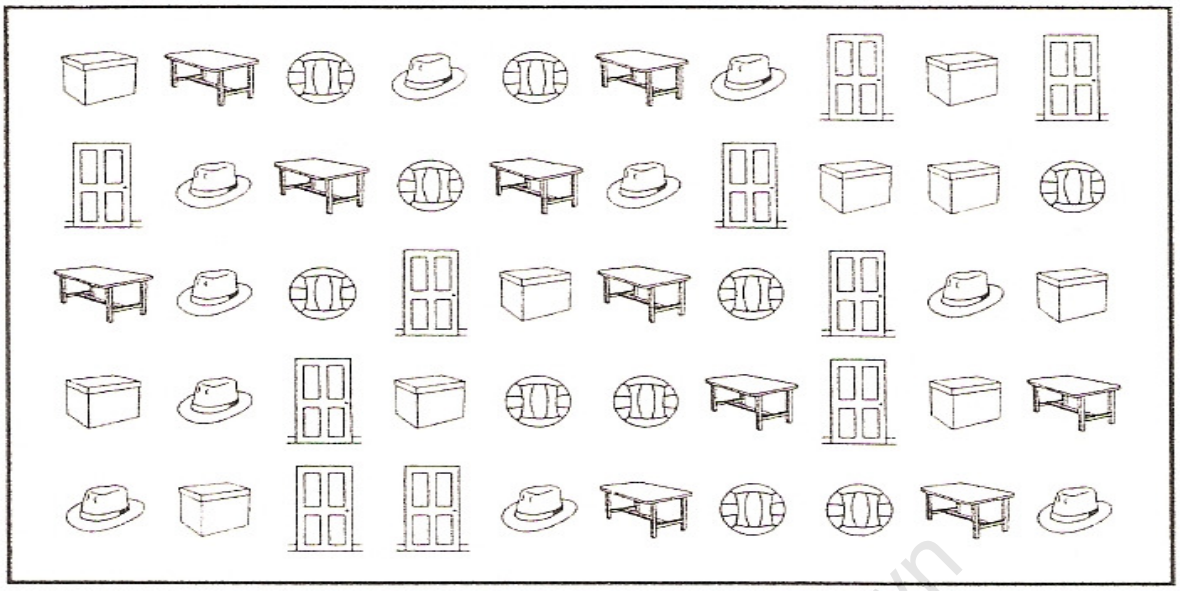

Figure A1. Picture naming sequence example

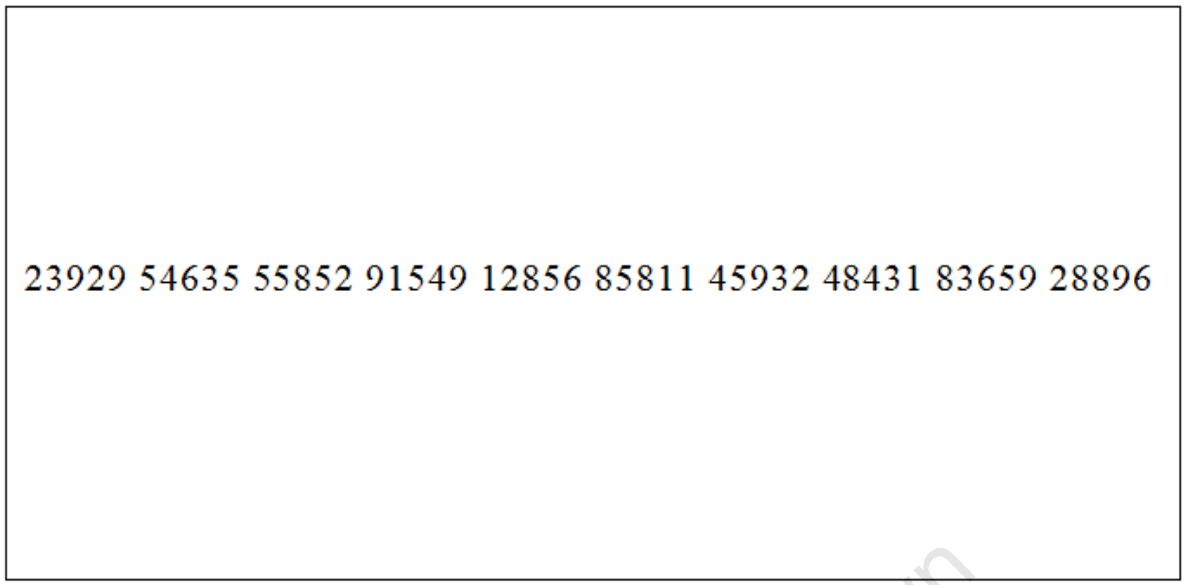

Figure A2. Digit naming sequence example.

APPENDIX B

Consent form

Toestemming deur Ouers/Ingeligte Instemming tot Navorsing

Naam van Studie: Korrelasie van Brein Effekte in Fetale Alkohol Spektrum Kwale

U en u kind _____ word genooi om deel te neem aan ’n navorsingsstudie waarin ons kinders se ontwikkeling sal ondersoek. Lees asseblief hierdie vorm deeglik deur en vra asseblief enige vrae wat u mag hê voordat u instem om aan die studie deel te neem. Die studie word onderneem deur Ernesta Meintjes, Ph.D., en Christopher Molteno, M.D., aan die Universiteit van Kaapstad, in samewerking met Sandra W. Jacobson, Ph.D., en Joseph L. Jacobson, Ph.D., van Wayne Staats-Universiteit in Amerika. Wayne Staats-Universiteit finansier die navorsing.

Doel van die studie: Die doel van die studie is om nuwe metodes te gebruik waarmee die brein bestudeer kan word, naamlik MRI prentjies van die brein, om beter te probeer verstaan hoe rook en die drink van alkohol tydens swangerskap kinders se ontwikkeling kan beïnvloed. Ons verwag dat omtrent 45 kinders van Kaapstad en 30 kinders van Detroit in Amerika aan die studie sal deelneem.

Metodes: Indien u en u kind deelneem aan die studie sal ons bestuurder julle oplaai en vir twee halfdag besoeke na die Universiteit van Kaapstad toe bring – by die Kinder Ontwikkeling navorsings laboratorium by die Universiteit van Kaapstad, en elke besoek sal omtrent 5 ure neem. Die eerste besoek sal u kind ‘n reeks eenvoudige take doen wat met lees, rekenkunde, aandag, vinger tik en verbale leer te doen het. In een taak wat op video opgeneem word, sal ‘n elektrode op die vel langs my kind se oog geplaas word, en ‘n blasie lug sal veroorsaak dat die oog knip terwyl ‘n geluid gehoor word en na ‘n video gekyk word. Ons sal jou kind weeg, meet, en foto’s van hom/haar neem. Ons sal vir u vrae vra oor u kind se gedrag, hoe hy/sy doen in die skool, sy/haar gesondheid, spanning in u daaglikse lewe, en u huidige drank- en dwelmgebruik, indien wel. Ons sal u ook vra om ’n vorm te teken waarin u vir u kind se onderwyser vra om ’n vorm te voltooi waarin inligting verskaf word aangaande u kind se gedrag by die skool. Party van die take sal op video opgeneem word; ander sal op papier neergeskryf word. Ons sal ’n kodenommer gebruik op alle inligting wat

ons versamel, nie u naam nie. Ons mag dalk die video's en foto's gebruik om ons personeel op te lei of in aanbiedings van die studie se resultate by wetenskaplike kongresse, maar ons sal nooit u of u kind se name gebruik nie.

Voordele: In hierdie studie sal die sielkundige ondersoek en MRI prentjies slegs vir navorsings doeleindes gebruik word. Indien enige abnormaliteit of probleem waargeneem word sal ons vir u daarvan sê en u verwys na 'n dokter en/of vir herstellende/remediërende hulp. Geen inligting aangaande u kind sal uitgegee word vir mediese of opvoedkundige doeleindes nie tensy u dit skriftelik versoek.

Risiko's: Indien daar op enige stadium tydens die studie kommer is dat kindermishandeling moontlik plaasgevind het, sal hierdie inligting aan die toepaslike owerhede gerapporteer word. Party van die vrae oor spanning in u daaglikse lewe, rook, en die gebruik van alkohol en dwelms mag u ontstel. Indien u daarin belangstel sal ons u verwys na iemand wat u kan help.

Navorsings Verwante Beserings: As u of u kind seer kry tydens hierdie studie sal u behandeling ontvang. Eerstehulp, noodbehandeling, en opvolg sorg sal beskikbaar wees, soos benodig. Geen terugbetaling, vergoeding, of gratis mediese sorg word deur Wayne Staats-Universiteit aangebied nie. Indien u dink dat u kind seergekry het as gevolg van sy/haar deelname aan die studie moet u die navorser dadelik laat weet.

Koste: U en u kind hoef niks te betaal om deel te neem aan hierdie studie nie.

Vergoeding: Vir u deelname aan hierdie navorsingsstudie sal ons u R100 ($20) betaal vir elke besoek en ons sal vir u kind 'n klein geskenkie gee.

Vertroulikheid: Ons sal alle inligting wat ons oor u en u kind versamel het tydens hierdie studie geheim hou, tot die mate wat die wet dit toelaat. U en u kind sal in die navorsingsrekords deur 'n kodenommer geïdentifiseer word. Ons sal geen inligting wat u of u kind by name bekend maak uitgee nie tensy u vir ons skriftelike toestemming gee. U rekords

mag egter hersien word deur die borge van die studie, die Menslike Navorsingskomitee by Wayne Staats-Universiteit, of ander regeringsliggame.

Vrywillige Deelname/Onttrekking: U deelname aan hierdie studie is vrywillig. U kan kies om saam met u kind deel te neem aan die studie en later van besluit verander en ophou. U en u kind het ook die reg om ’n vraag nie te antwoord nie of om enige taak of onderhoud te stop

voordat dit klaar is. Die navorser, of die borg, mag u kind se deelname aan die studie stop sonder dat u daarmee hoef saam te stem.

Vrae: Indien u nou of op ’n later stadium enige vrae het kan u dokters Ernesta Meintjes of Christopher Molteno skakel by 021-406-6210 of dokters Sandra W. Jacobson of Joseph Jacobson by 091-313-993-5454. Indien u enige vrae het of bekommerd is oor u of u kind se regte as ’n deelnemer aan die studie, kan u die voorsitter van die Menslike Navorsingskomitee by Wayne Staats-Universiteit skakel (091-313-577-1628).

Toestemming om aan die navorsingsstudie deel te neem: Om vrywilliglik in te stem om saam met u kind aan hierdie studie deel te neem, moet u hieronder teken. Indien u kies om saam met u kind deel te neem, mag u of u kind op enige stadium u deelname stop. Nie u of u kind gee enige van julle regte op deur hierdie vorm te teken nie. U handtekening wys dat u hierdie vorm heeltemal deurgelees het, of dat dit aan u voorgelees is, insluitende die dele wat die risiko’s en voordele verduidelik, en dat ons al u vrae beantwoord het. Ons sal vir u ’n afskrif van hierdie toestemmingsvorm gee om huis toe te vat.

_____ _____

Handtekening van ouer / voog Datum

_____ _____

Naam van ouer / voog in drukskrif Tyd

_____	_____
Mondelikse Instemming (kinders 7-12 jaar)	Datum
_____	_____
**Handtekening van Getuie (wanneer van toepassing)	Datum
_____	_____
Naam van Getuie in drukskrif	Tyd
_____	_____
Handtekening van persoon wat toestemming ontvang	Datum
_____	_____
Naam van persoon wat toestemming ontvang in drukskrif	Tyd

** Gebruik wanneer die toestemmingsvorm aan die ouer / voog voorgelees is (m.a.w. in gevalle van ongeletterdheid, blindheid, vertaling in 'n ander taal)

I guarantee that this translation is accurate

E. Meintjes

_____

ERNESTA M MEINTJES, PhD

Research Officer and Senior Lecturer

MRC/UCT Medical Imaging Research Unit

APPENDIX C

Comparison of the Exposed versus Non-exposed Groups: Boxplots

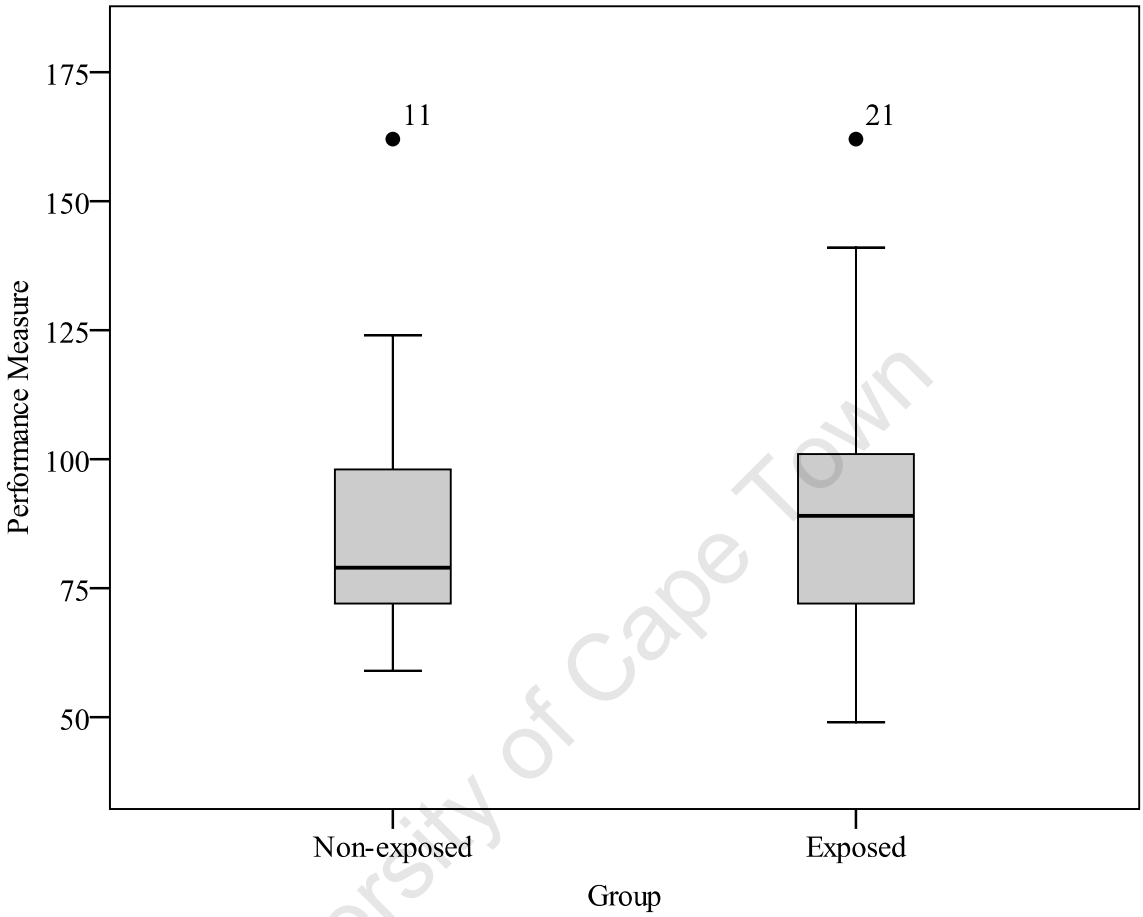

Figure C1. Boxplot showing the distribution of the PhAB phonological processing speed performance measures. Case 11 is a significant outlier in the non-exposed group and case 21 is an outlier in the exposed group.

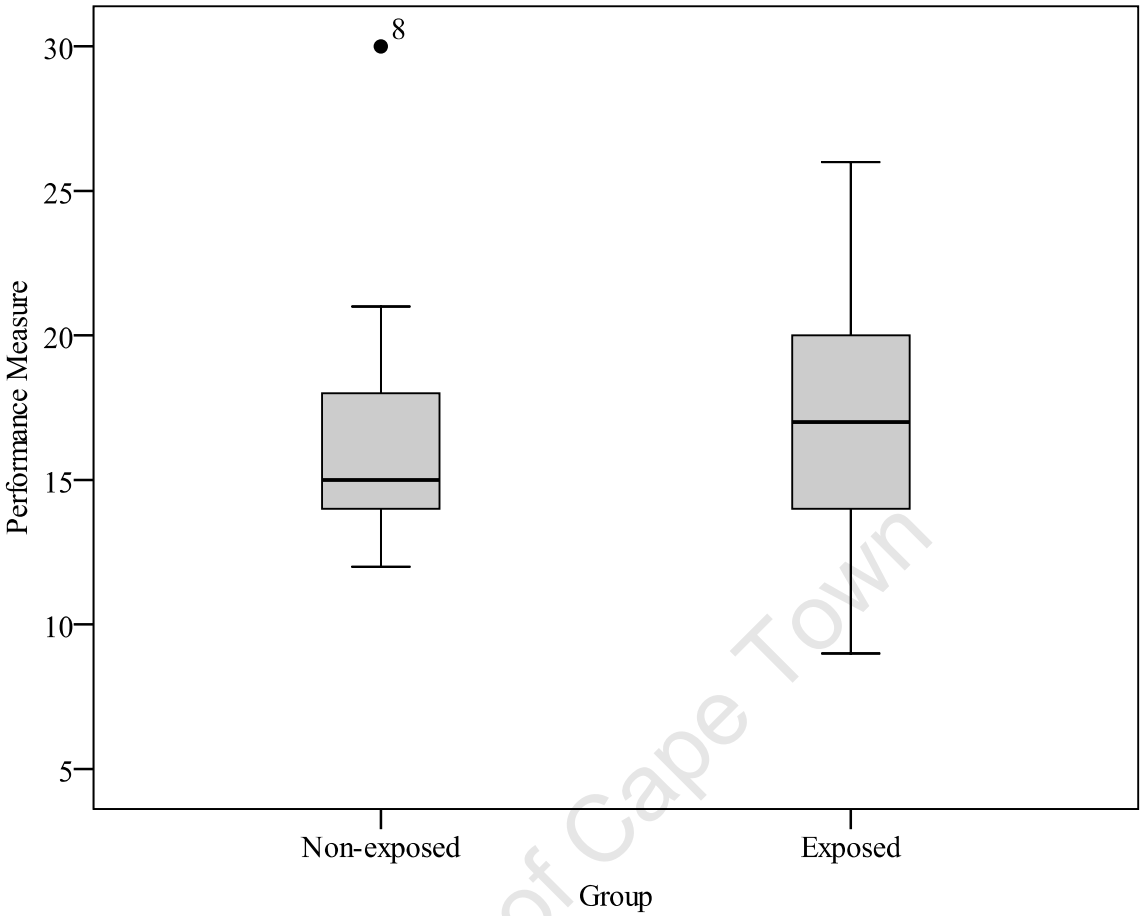

Figure C2. Boxplot showing the distribution of the PhAB non-phonological fluency performance measures. Case 18 is a significant outlier in the non-exposed group.

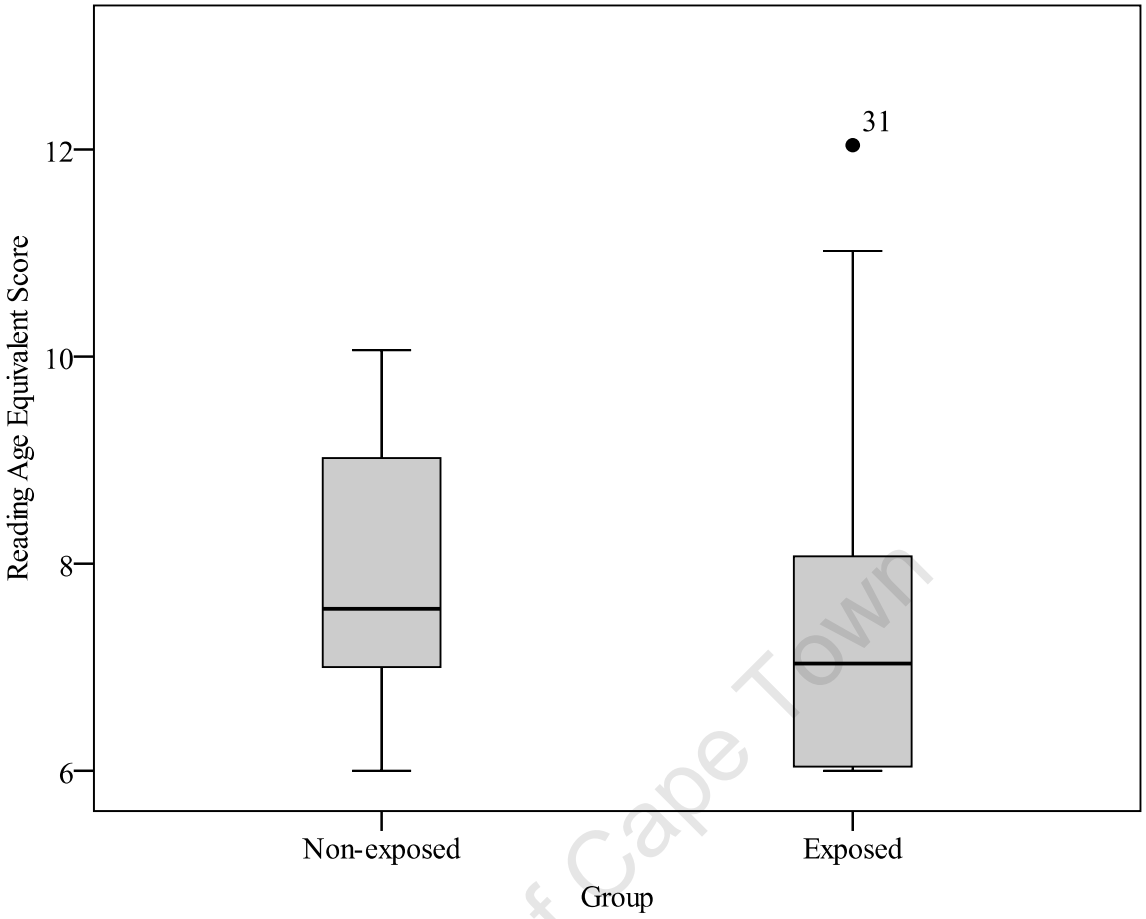

Figure C3. Boxplot showing the distribution of the NARA rate age equivalent scores. Case 31 is a significant outlier in the exposed group.

APPENDIX D

Comparison of the FAS/pFAS, OHE and Control Group: Boxplots

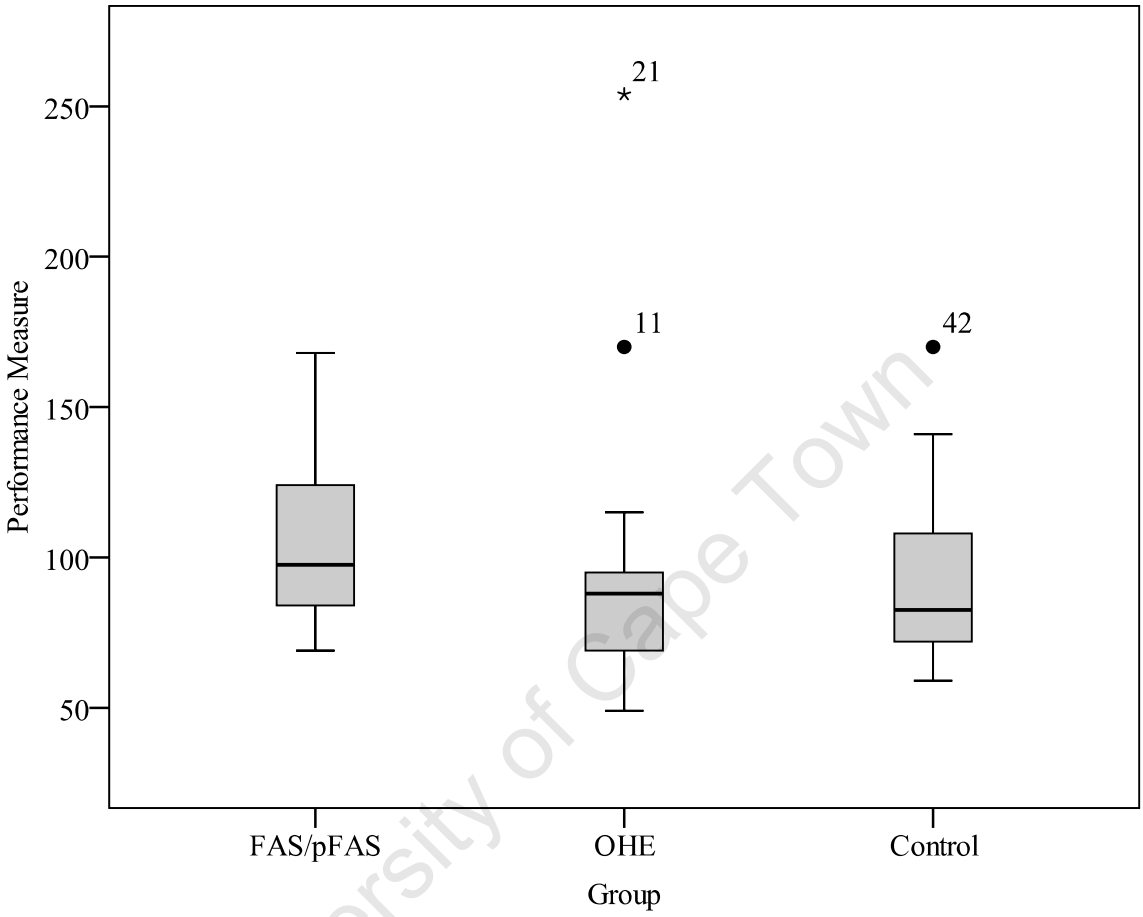

Figure D1. Boxplot showing the distribution of the PhAB phonological processing speed performance measures. Cases 11 and 21 are significant outliers in the OHE group and case 42 is a significant outlier in the Control group.

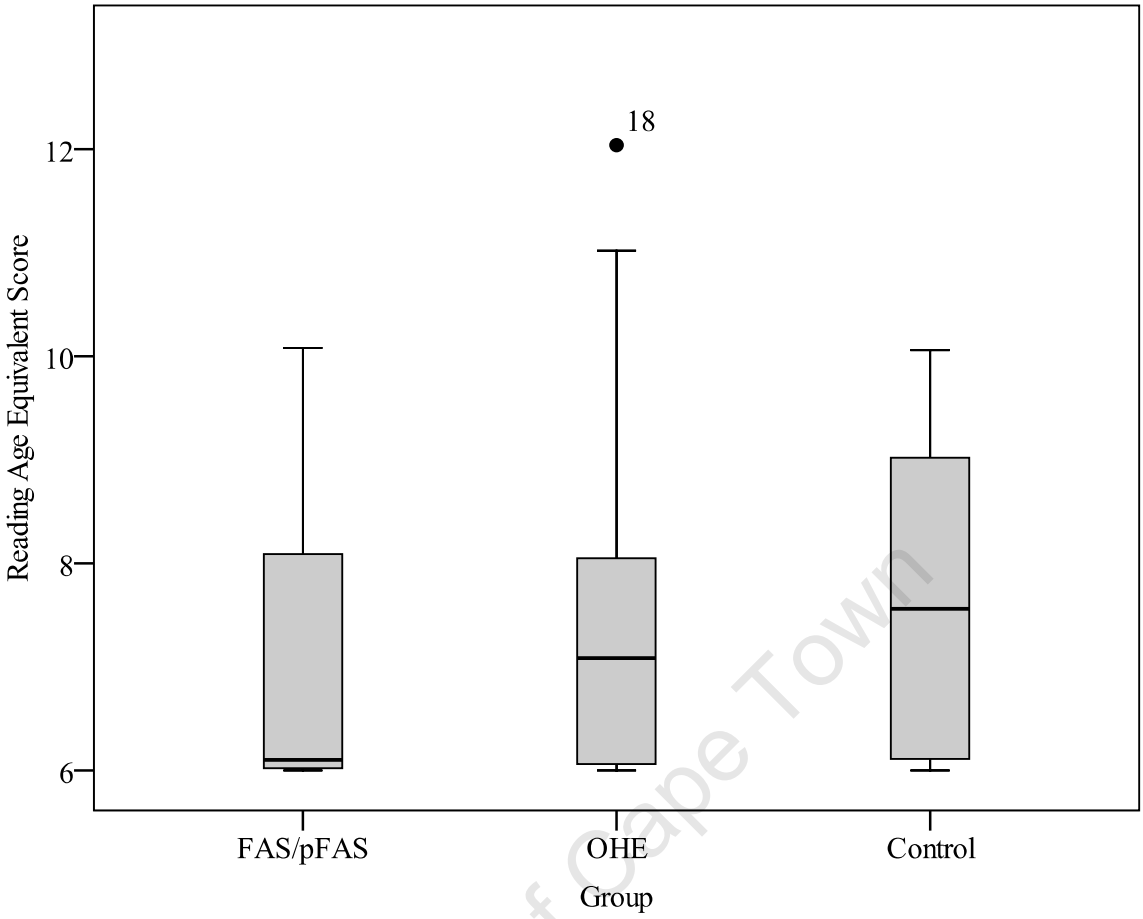

Figure D2. Boxplot showing the distribution of the NARA rate age equivalent scores. Case 18 is a significant outlier in the OHE group.

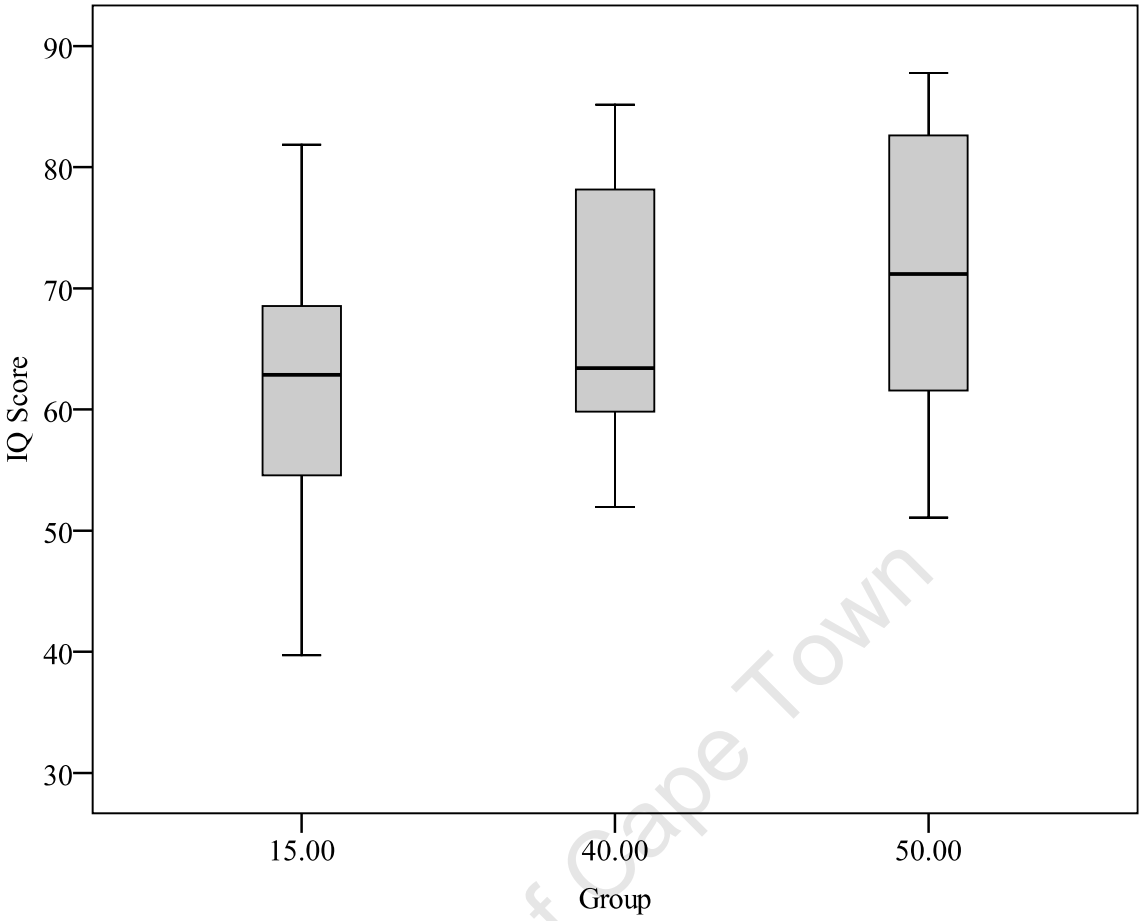

Figure D3. Boxplot showing the distribution of IQ scores.

APPENDIX E

Multiple Regression Analyses: Boxplots

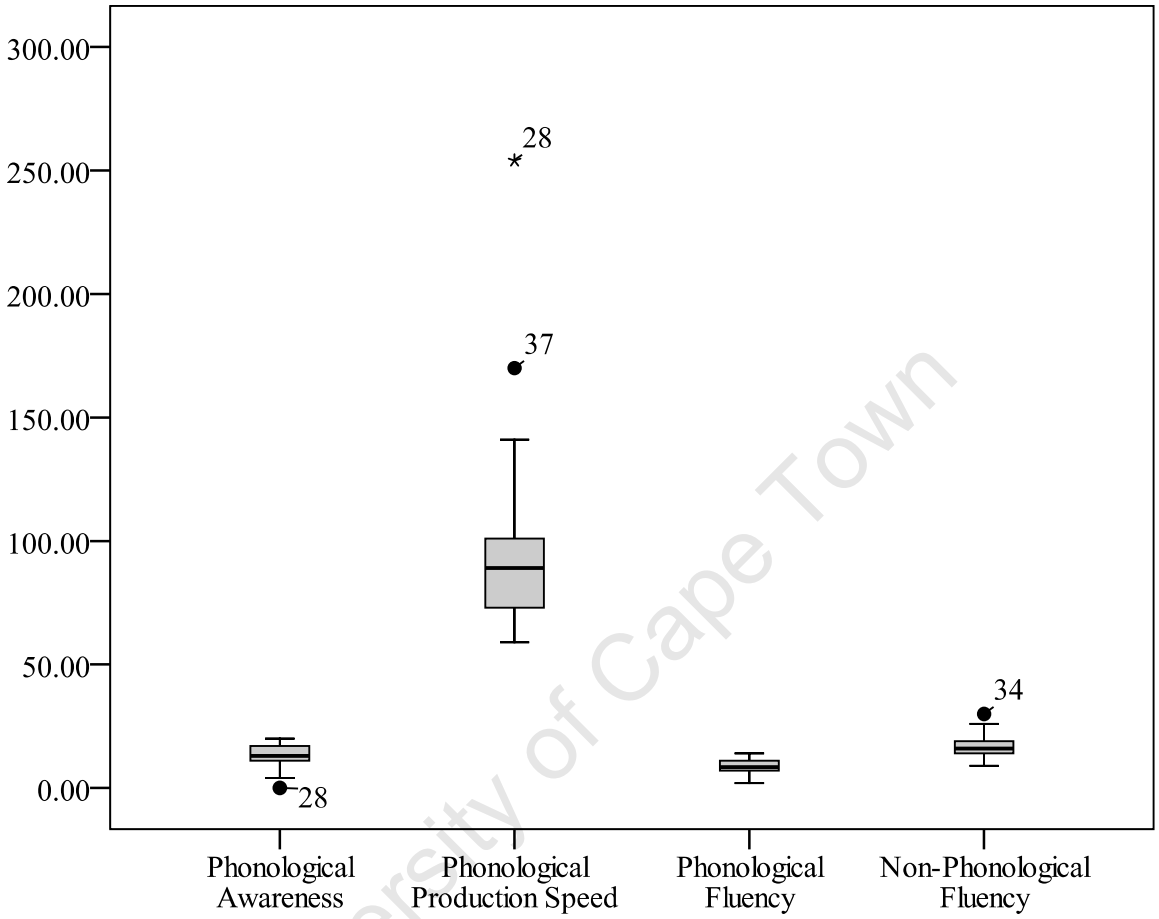

Figure E1. Boxplot showing the distribution of scores on the four PhAB performance measures. Case 28 is a significant outlier on the measure of phonological awareness, cases 28 and 37 are significant outliers on the measure of phonological production speed, and case 34 is a significant outlier on the measure of non-phonological fluency.

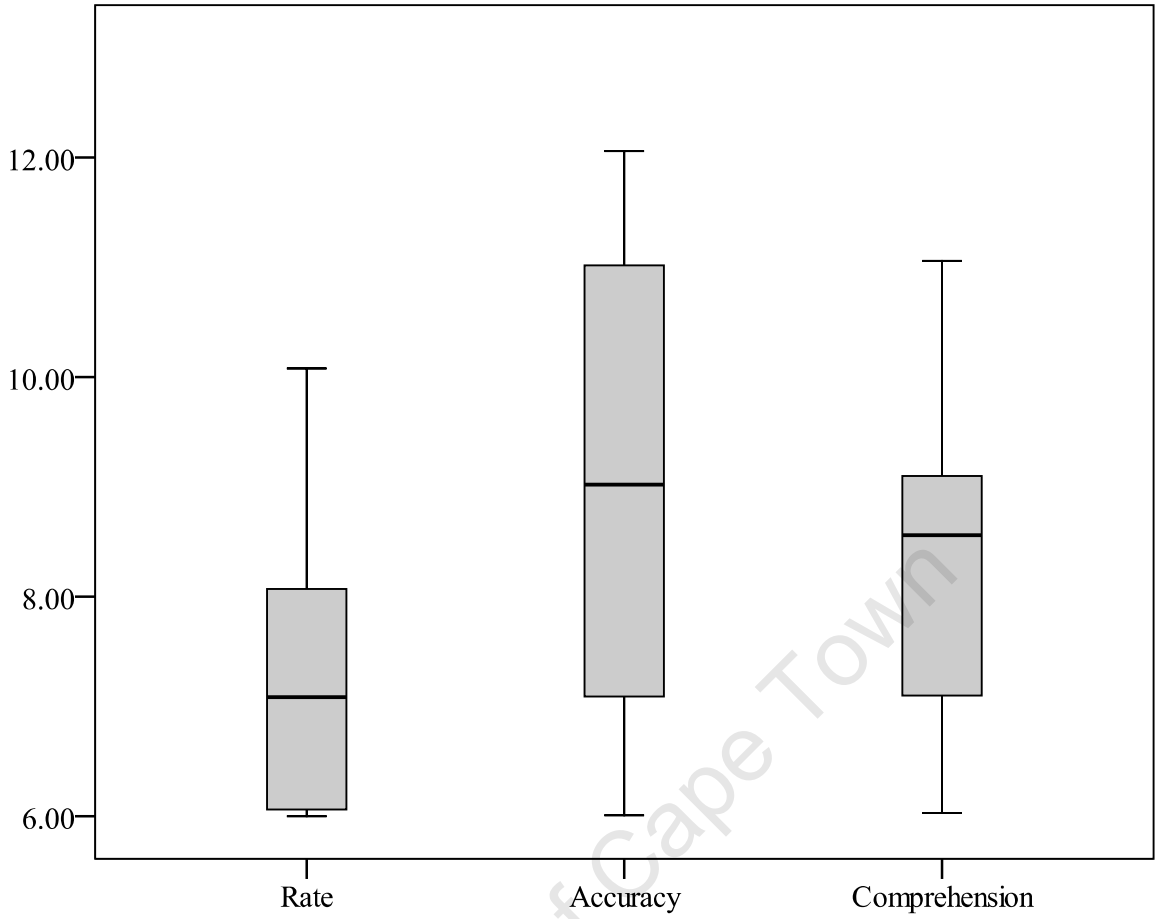

Figure E2. Boxplot showing the distribution of the NARA age equivalent scores.

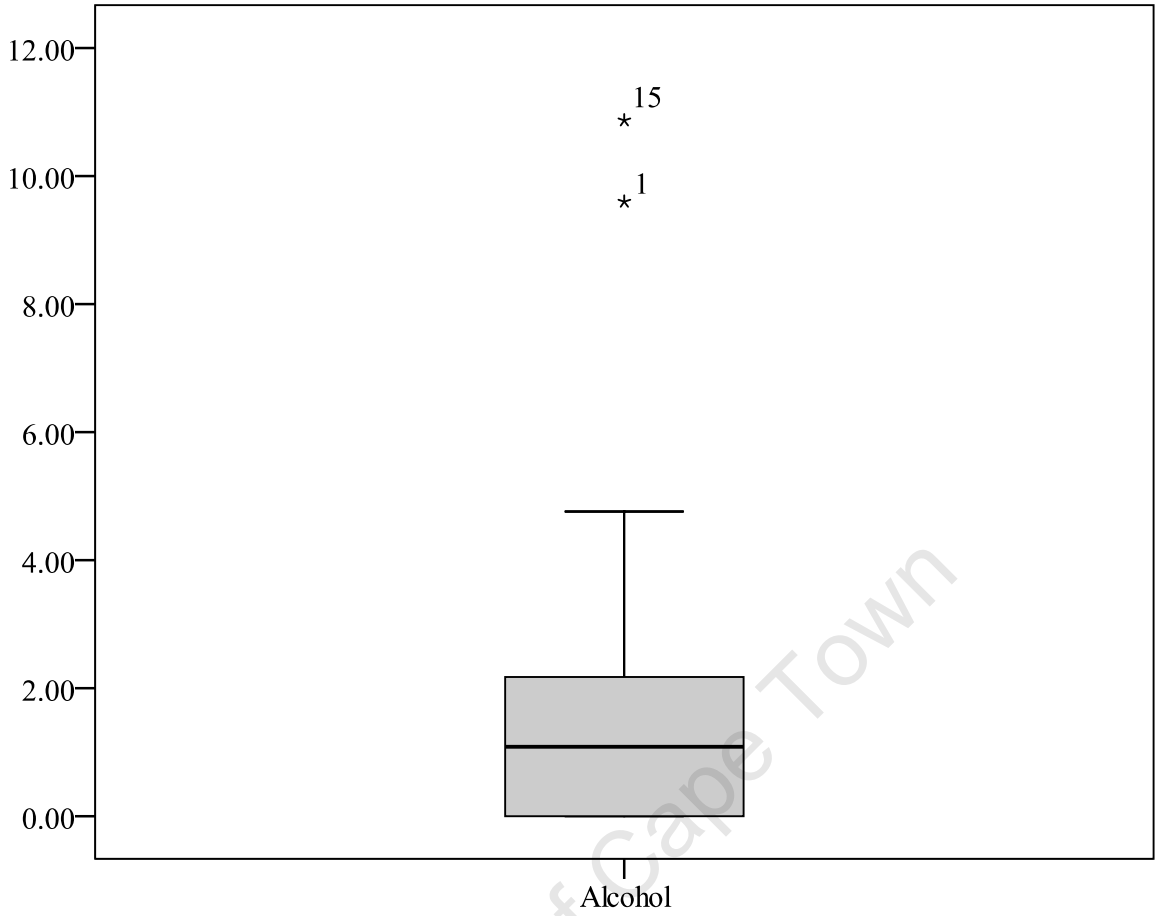

Figure E3. Boxplot showing the distribution of the alcohol variable. Cases 1 and 15 are significant outliers.

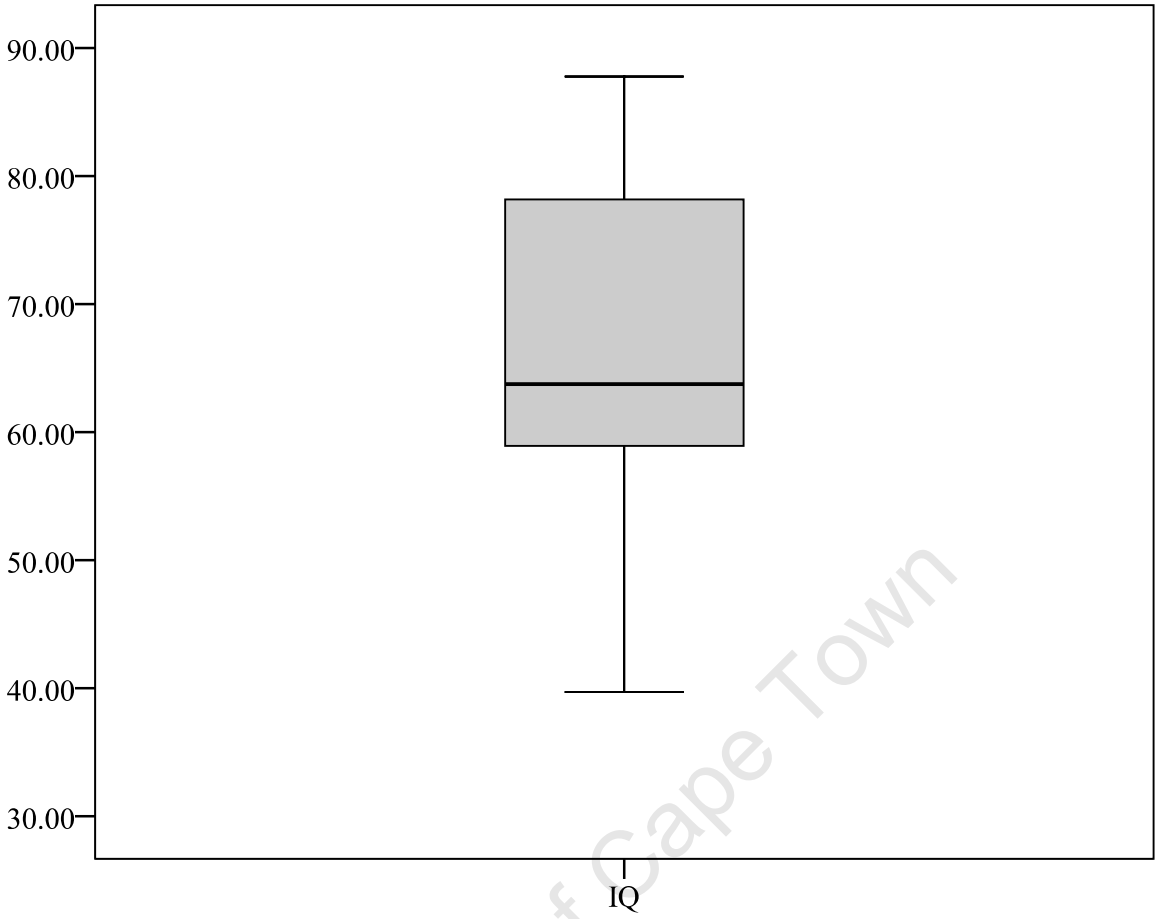

Figure E4. Boxplot showing the distribution of the *IQ* variable.

APPENDIX F

Multiple Regression-Based Analyses: Correlation Matrices

Table F1. Correlation Matrix for Measures of Prenatal Alcohol Exposure, and Intellectual Functioning, and PhAB Performance Measures

	Alcohol[a]	IQ	PA	PPS[a]	PF	NPF
Alcohol	1.00					
IQ	-.27*	1.00				
PA	-.14	.58****	1.00			
PPS[a]	.31*	-.30*	-.71******	1.00		
PF	-.18	.47**	.68*****	-.45**	1.00	
NPF	-.07	.06	.27^	-.13	.33*	1.00

Note. PA = PhAB phonological awareness; PPS = PhAB phonological production speed; PF = PhAB phonological fluency; NPF = PhAB non-phonological fluency. Statistics presented in Pearson's correlation coefficient (*r*) unless otherwise stated.

[a]Statistics presented in Spearman's correlation coefficient (*rho*).

^*p* (one-tailed) < .10, **p* (one-tailed) < .05, ***p* (one-tailed)<.01, ****p* (one-tailed) < .0001, *****p* (one-tailed) < .000001, *****p* (one-tailed) < .0000001.

Table F2. Correlation Matrix for Level of Prenatal Alcohol Exposure, Intellectual Functioning, PhAB Performance Measures and the *NARA* Age Equivalent Scores

Variable	Alcohol[a]	IQ	PA	PPS[a]	PF	NR	NA	NC
Alcohol	1.00							
IQ	-.27*	1.00						
PA	-.14	.58****	1.00					
PPS[a]	.31*	-.30*	-.71******	1.00				
PF	-.18	.47**	.68*****	-.45**	1.00			
NR	-.33*	.42**	.80********	-.74*******	.35*	1.00		
NA[a]	-.25^	.46**	.78********	-.64****	.41**	.80*********	1.00	
NC[a]	-.24^	.61****	.77*******	-.59***	.47**	.75*******	.90**********	1.00

Note. PA = Phonological awareness; PPS = Phonological production speed;

PF = phonological fluency. NR = Rate; NA = Accuracy; NC = Comprehension.

Statistics presented in Pearson's correlation coefficient (*r*) unless otherwise stated.

[a]Statistics presented in Spearman's correlation coefficient (*rho*).

^*p*(one-tailed) < .10, **p*(one-tailed) < .05, ***p*(one-tailed)<.01, ****p*(one-tailed) < .001,

*****p*(one-tailed) < .0001; ******p*(one-tailed) < .00001; *******p*(one-tailed) < .0000001,

********p*(one-tailed) < .00000001, *********p*(one-tailed) < .000000001, **********p*(one-tailed) < .0000000001,

***********p*(one-tailed) < .00000000000001.

APPENDIX G

Multiple Regression-Based Analyses: Case Diagnostics showing Influential Cases

Table G1. Case Diagnostics: PhAB phonological production speed

Case Number	Standardised Residual Value	Mahalanobis Distance	Cook's Distance	Centered Leverage Value	Covariance Ratio (CVR)
1	0.17	7.74	0.00	0.19	1.40*
15	1.27	11.12	0.32	0.27*	1.28*
28	2.03	5.57	0.31	0.14	0.44*
37	3.16*	1.98	0.17	0.02	0.86

Note. *Values of cases which might be influencing the regression model.

Table G2. Case Diagnostics: *NARA rate*

Case Number	Standardised Residual Value	Mahalanobis Distance	Cook's Distance	Centered Leverage Value	Covariance Ratio (CVR)
1	0.29	7.78	0.00	0.19	1.48
15	0.25	15.00	0.01	0.37	1.91*
28	1.24	10.23	0.13	0.25	1.13
37	0.39	11.56	0.02	0.28	1.65*

Note. *Values of cases which might be influencing the regression model.

Table G3. Case Diagnostics: *NARA accuracy*

Case Number	Standardised Residual Value	Mahalanobis Distance	Cook's Distance	Centered Leverage Value	Covariance Ratio (CVR)
1	0.92	7.78	0.05	0.19	1.26*
15	-0.48	15.00	0.04	0.37	1.82*
27	0.04	9.19	0.00	0.22	1.57*
28	0.77	10.23	0.05	0.25	1.42
37	-0.27	11.56	0.01	0.28	1.68*

Note. *Values of cases which might be influencing the regression model.

Table G4. Case Diagnostics: *NARA comprehension*

Case Number	Standardised Residual Value	Mahalanobis Distance	Cook's Distance	Centered Leverage Value	Covariance Ratio (CVR)
1	0.43	15.43	0.03	0.38	1.88*
15	-0.91	12.95	0.11	0.32	1.45
27	-0.24	9.07	0.00	0.22	1.55*
28	-0.85	10.35	0.06	0.25	1.54*
33	-2.39	3.05	0.11	0.07	0.41*
37	-0.61	11.26	0.04	0.27	1.54*

Note. *Values of cases which might be influencing the regression model.

APPENDIX H

Multiple Regression-Based Analyses: Scatterplots of the NARA Age Equivalent Scores Regression Values

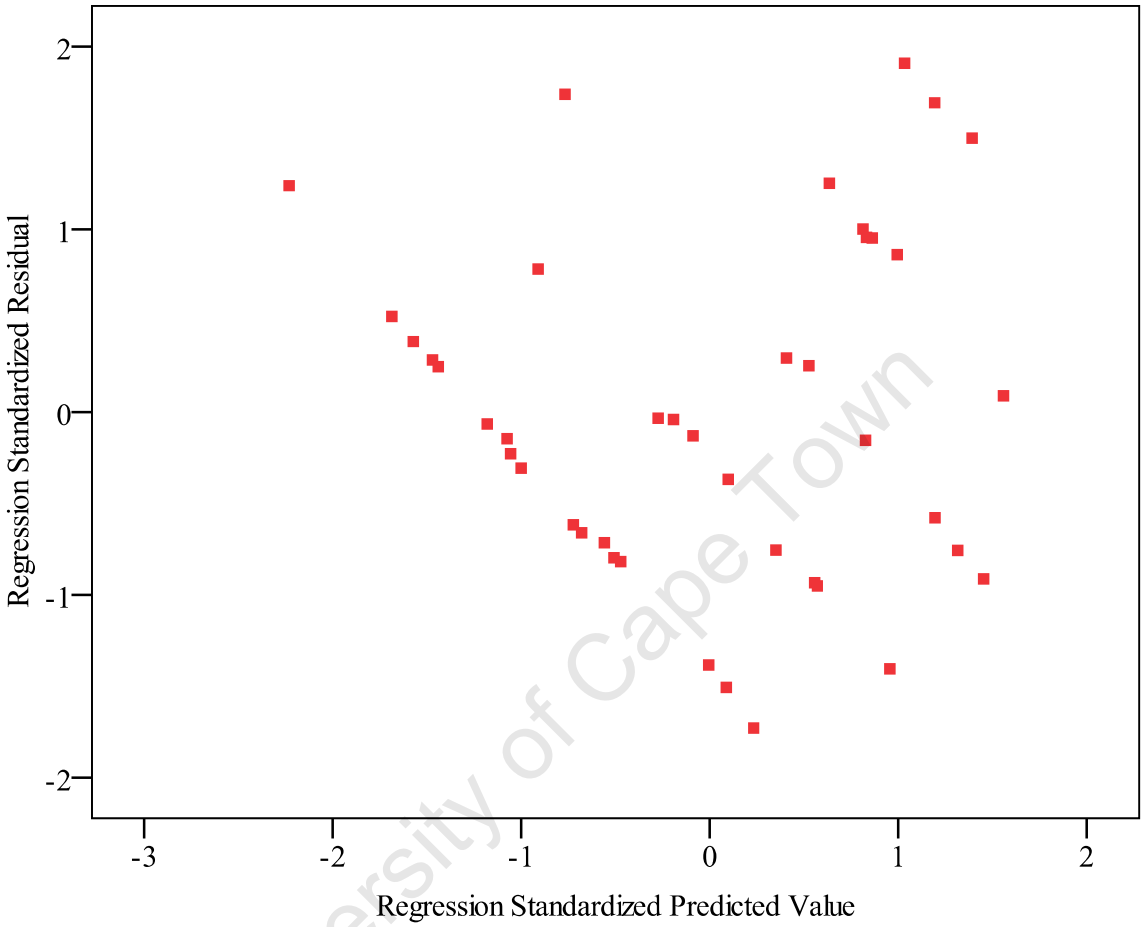

Figure H1. Scatterplot showing heteroscedasticity within the NARA rate age equivalent scores residual values.

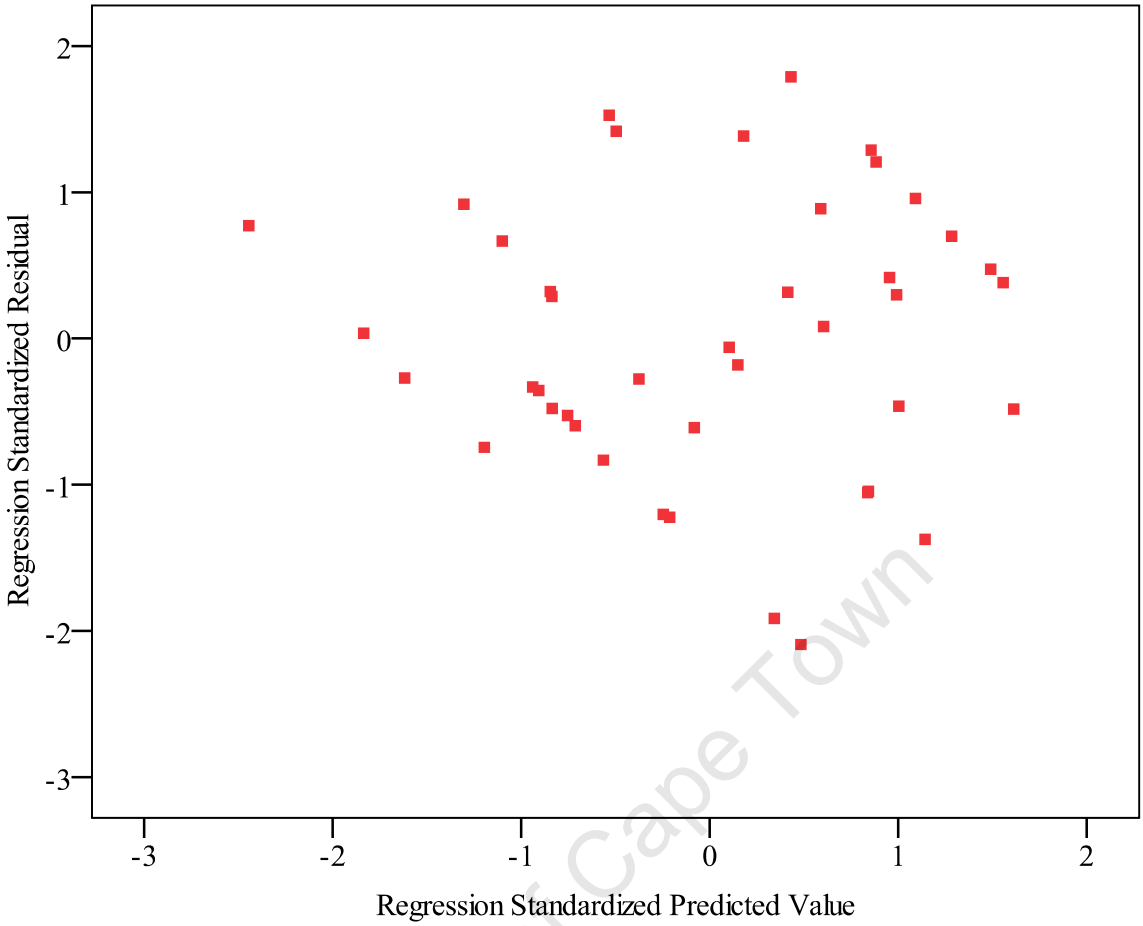

Figure H2. Scatterplot showing heteroscedasticity within the NARA accuracy age equivalent scores residual values.

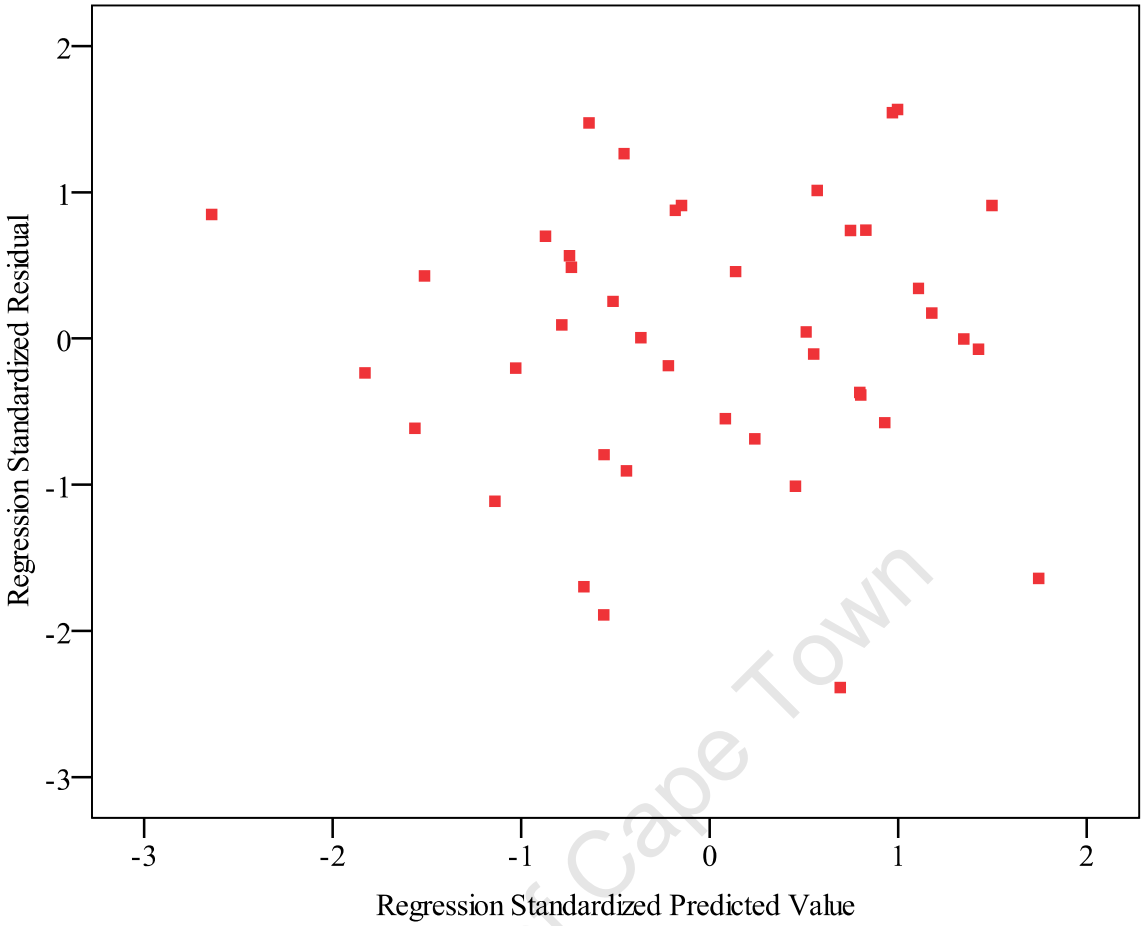

Figure H3. Scatterplot showing heteroscedasticity within the NARA comprehension age equivalent scores residual values.